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AVIATION AND AERONAUTICAL ENGINEERING

JAN 28 1921

General View of Paris Aeronautical Exposition

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VOLUME VII
Number 12

SPECIAL FEATURES

IMPRESSIONS OF THE CHICAGO AERONAUTICAL SHOW
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THE GOODYEAR TYPE A PONY BLIMP
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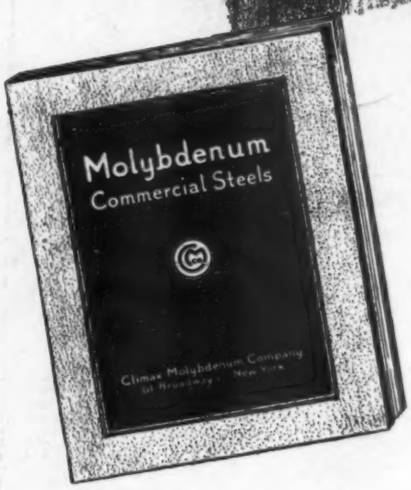

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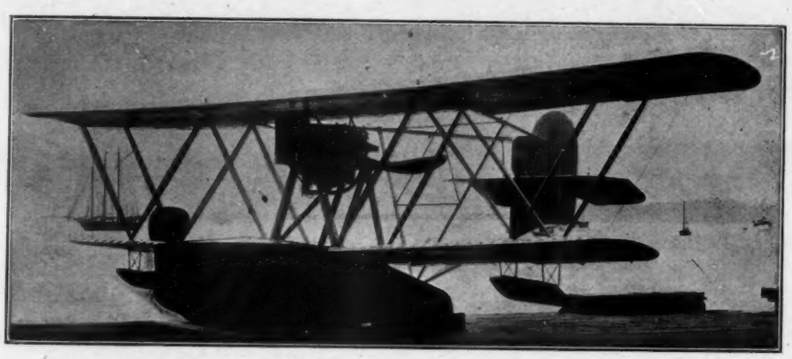

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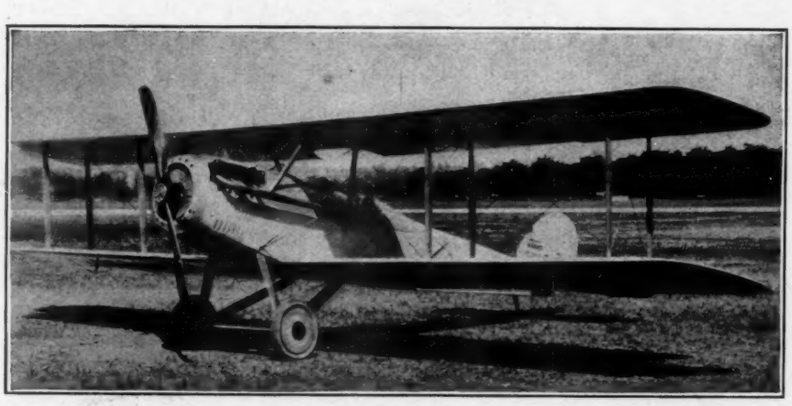

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VOL. VII. NO. 12

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AVIATION AND AERONAUTICAL ENGINEERING

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Vol. VII | January 15, 1920 | No. 12

THAT the Middle West will ere long become the most important market for aircraft manufacturers in this country seems a foregone conclusion to anyone who has followed the spread of interest in aeronautical matters in that section. Since the Armistice released the aircraft industry from its war effort, land machines and seaplanes have been acquired by many sportsmen and businessmen of the Middle West who were quick to grasp the possibilities of aircraft for utilitarian and pleasure purposes. Some use flying machines for commuting between their country homes and business centers; others employ airplanes to supervise their extensive farms; still others fly for the mere exhilaration flight offers to the red-blooded sportsman. Of course, in addition to this civil aviation proper, a great deal of commercial flying is being done on a small scale, such as ferrying passengers across large rivers and lakes, joy riding, parcel carrying, etc.

Still commercial air transport on schedule, by the use of large comfortably fitted airplanes, such as has become a daily occurrence in Paris and in London, has not as yet come into being in this country. It is not that we lack the proper machines; the Martin Transport, the Curtiss Eagle, the Lawson Airliner, all prove the contrary. What this country needs for building up a merchant air service—and this cannot be emphasized too strongly, nor often enough—is a chain of properly laid out and equipped aerodromes. It stands to reason that, just as the merchant marine was unthinkable without harbors and lighthouses, and automobile traffic needs good roads, commercial aviation requires suitable landing stations where airplanes can find shelter, supplies and repair when needed.

The Army Air Service and the Air Mail Service have already done much good with their campaign to enlighten the country at large in respect to these all important needs of commercial aviation. The Army Air Service has in particular done pioneering work by outlining last year at the Southeastern Aeronautical Congress its landing field policy. Municipalities were thus made cognizant of just what kind of ground establishments are required for safe aerial navigation; that if they conformed in the outlay of aerodromes with the specifications of the Army, the latter would furnish them with steel hangars free of charge. This policy has had an excellent effect on progressive communities, for these promptly availed themselves of the offer.

However, only a small beginning has so far been made, for a truly enormous task awaits this country in the organization of airways. While the initiative in this field will probably come from the municipalities, just as it did in the matter of marine harbors, it seems that the federal government should nevertheless take a stand as to the form of assistance it may be willing to render in such case, since commercial aviation represents a public utility of great potentiality.

This question is closely related to the great problem of how civil aviation is to be regulated in this country without it being stifled by too many government restrictions and yet be prevented from falling into a state of chaos, which would undoubtedly occur if every state is permitted to regulate air navigation individually. The inspection, registration and licensing of aircraft should be made a federal function, as should the licensing of pilots and navigators, and the drawing up of the rules of the air. In brief, *one aerial law* should be in force over the entire territory of the United States, for the radius of action of aircraft makes state control entirely impracticable.

Rank Titles for Air Officers

One of the many delicate problems which confront the proposed creation of a single air service, and which often cause needless opposition on the part of persons otherwise more or less favorably inclined toward such a scheme, is the question of rank titles.

Most bills providing for a unified air service merely follow army practice in this respect. This has on one hand led to opposition from military men, who feel that to create so many young generals and colonels would lessen the importance justly attributed to these ranks. On the other hand, most Navy officers, who would be taken over bodily by the operation of such a legislation, will have none of it, because they do not believe it proper for captains and admirals to take the rank of colonel and general.

The Royal Air Force of England has solved this puzzling problem in a manner that may have a suggestion in it for the proposers of our air force bills. Instead of assuming army or navy rank titles, R. A. F. officers are given titles entirely distinct from those used by the land and sea forces, although of strictly corresponding rank. The rank titles of the R. A. F. are, from the top of the hierarchy down: Marshal of the Air, Air Chief Marshal, Air Vice Marshal, Air Commodore, Group Captain, Wing Commander, Squadron Leader, Flight Lieutenant, Flying Officer, Pilot Officer.

As these ranks correspond to those of the British navy and army, they take precedence accordingly, while the distinctive titles spare the susceptibilities of former army and navy officers. This scheme seems therefore entirely commendable.

Impressions of the Chicago Aeronautical Show

By Alexander Klemin

The dominant feature of the Chicago Aeronautical Show was its commercial character. With the exception of a Navy training plane and a war-worn Spad, the machines exhibited were purely transport and pleasure types. Aircraft manufacturers did not present any military craft because they undoubtedly realize that the time has come where commercial aircraft will exert an ever growing appeal to the public, which in the end will become the principal user of flying machines and airships. It is most encouraging that this should be so.

Aeromarine Model 50 Flying Boat

One of the most striking exhibits of the Show was the Aeromarine model 50 flying boat, beautifully finished in dazzling white. This machine is illustrative of a good many tendencies of modern commercial design and has very clean lines; at the same time it does not depart from standard practice. Its general dimensions are identical with the Model 40 described elsewhere in this issue; the majority of changes appear in the equipment of the boat hull.

A step is provided for access into the hull, which arrangement should appeal to the public as it facilitates going on board. The seats for the pilot and the two passengers are most comfortably upholstered. The two watertight doors on either side do not interfere in any way with the structural strength of the hull. A number of small drawers and compartments are provided in front of the pilot and at the sides of the machine. The controls are so arranged as to leave the cockpit entirely free of wires; thus the rudder-bar is duplicated by another bar to which it is connected by wires carried beneath the floor. A wheel-control is provided, but with this important modification that the movement of the wheel is transmitted through bevel gearing; a gear shaft inside the main control column and a universal joint to a horizontal shaft with a universal joint at its other end. Elevator and aileron control is thereby achieved without a single wire cluttering up the cockpit.

While the passengers and pilot are totally enclosed, the vision is quite good through transparent pyralin, and the pilot has a number of moveable windows in front of him. A noticeable feature of the pusher design is the distance available between the front radiator and the engine. The radiator might be almost considered a free-fair radiator. The engine mounting deserves careful study as a thoroughly braced job. In the rear part of the engine the two upper struts are apparently not crossed-braced, but the side struts are tied together by a tube in front of the engine. It is curious to note what an enormous vertical fin is used for this machine, a feature which is rendered necessary by the large lateral era of the forward part of the hull.

The Aeromarine Flying Yacht, as Model 50 is designated, is fitted with an Aeromarine Model L 130 hp. vertical 6-cyl. engine, which gives it a high speed of 80 m.p.h.

Curtiss Seagull

The Curtiss Seagull is another machine of the three-seater, flying-boat type, approximately the same size as the Aeromarine Model 50. Equipped with the Curtiss Six 150 hp. engine, it makes a maximum speed of 76 m.p.h., and a minimum of 48.5 m.p.h. This seaplane is in many respects similar to the Curtiss MF boats used so extensively during the war for the training of Navy aviators, and the main modifications of the MF are in the arrangement of the hull, in which a pilot or two passengers are carried.

The hull is provided with a much larger wind-shield than is customary in training planes, and lots of leg-room is provided for all of the occupants. A curious feature is found in the front control-stick. The rear control being further back on the side, the front stick is bent under the seat so that it works on the same shaft as the rear control-stick. This is a very clever piece of design, to get round what is always a difficult problem. It is interesting to note on this machine the employment of aluminum wing-floats, which come right up to the wing, and require only one strut for lateral bracing. Wing-tip floats have been braced in every imaginable way, and always with the introduction of a great deal of resistance. The Seagull solution is a particularly pleasing one.

In the wing-truss of the Seagull it is noticeable that two large skid-fins are provided although there is a dihedral in the machine. The lift-truss is so arranged that the wing-hinges are carried out at some distance from the hull, by the introduction of a pair of extra struts on either side. This gives the trussing perhaps not as clean an apearance as on the Aeromarine, but provides for an easy dissembly of the wing, without removal of the outer sections causing the center section to be disturbed in any way. The biplane is orthogonal, which is a great advantage in the mounting of a flying boat engine. While in the Seagull the engine mounting is rugged and amply strong with a huge strut, taking up the thrust of the pusher-propeller, there is no cross-bracing in the two forward engine struts. The pull of the lift wires is taken partly through the crank case of the engine, and the struts of the engine mounting transmit tension to the hull, which is not quite as it should be. It seems an inherent difficulty of flying boat design that the engine mounting is never quite clean or perfect, nor does the Seagull escape criticism in this respect.

A curious feature in this machine is the reappearance of a U bolt fitting under the wing-struts; this allows for a simple production job, and an easy alignment of landing and flying wires on the U bolt, without requiring the care being given to the angle of clips of the fittings. On the other hand, once a U bolt fitting is in position it is very hard to dissemble in any way. The only other seaplanes exhibited at the show, were the well known Curtiss N 9 and a large Navy training plane, both of which are too well known to call for special comment. In the construction of the hull, four separate water-tight compartments are included. Birds-eye maple and mahogany are used in the construction of the very solid box-like sides.

Curtiss Eagle

One of the exhibits attracting the most attention to the show was a three engine Curtiss Eagle. The visitors inspecting the interior of the machine formed a lengthy line before they could secure admittance to the ship. The gross weight of the machine is 7,500 lb. and the useful load is 2,300 lb., which is relatively very large for the comparatively low combined power of the three 150 hp. engines. The passengers sit in a very nicely arranged cockpit, with good vision through unbreakable glass windows. Very rationally a large opening is provided on either side of the cock-pit, where the pilots are seated, giving them excellent lateral vision, and also an opportunity to feel a lateral wind. No matter what may be said to the contrary, and in spite of the growing tendency to enclose both pilots and passengers, it would seem highly advantageous to provide such openings for the pilots.

It is a noteworthy feature in the design of this machine, and one which will no doubt be often followed in multi-engine practice that the comptometer and pressure gages for the two outer motors are mounted on the two wing nacelles, with a space of some 5 ft. between them and the pilot. While this introduces a difficulty of vision in unfavorable weather, it does away with the necessity of exceedingly long leads for the tachometers and gages. The motor mounting is to one side of the struts and directly on the lower wing. This would seem to provide with the very simplest form of mounting. The motor stream lining is very well carried out. It will be remembered that some time back, the English twin-motor DH-10 had the engine mounting between the wings changed to a mounting with the engines directly on the wing, with an improvement in performance of some 10 m.p.h. The same sort of mounting and stream-lining is used on a German airplane of which photographs recently appeared in AVIATION. This type of engine mounting on the wings seems to form a very rational method.

The Curtiss designers seem to be thoroughly converted to the idea of free air radiators, of which there are three on this machine. These radiators are of the standard honeycomb type. A good feature of the design is the provision of a number of louvers in the engine stream line, to provide plenty of air circulation.

As in other Curtiss designs, the fuselage is of two-ply veneer construction. The plys being diagonal and approximately at 90 deg. to one another, no pressure is used in the construction of these fuselages; the strips, about 3 in. in width, are formed on a special form. Cold glue is employed. This is somewhat surprising, as it has hitherto been considered that cold glue can only be efficiently applied under considerable pressure, and no pressure is employed in building up this job; satisfactory strength is nevertheless secured. A similar type of construction is used in the Curtiss Oriole, but in the large fuselage of the Eagle the body is divided in two parts along a horizontal plane. The provision of an enclosed fuselage leaving forward vision for the pilot has apparently not yet been solved so as to concord with aerodynamical streamline form. The Eagle fuselage has a very ugly hump, which undoubtedly increases its resistance, while in the rear part there is provided a very neat rear fairing leading to the extreme end. This rear fairing can only be embodied by placing both vertical fin and rudder well above the fuselage. This is a feature of which aeronautical engineers have been to some extent suspicious. Actual practice seems to demonstrate that there is no structural disadvantage in placing both fin and rudder high above the fuselage, and making the end of the body of perfect streamline form. The tail-skid is provided with a very sharp, powerful claw, which shortens the length of landing run very considerably. Apparently this claw only leaves a slight track on the field. In the hinges of the control-surfaces, the Curtiss Co. again show a very effective strap-hinge, which does away with the brake between the control-surface and the surface forward of it.

The chassis of the Eagle is somewhat original in form, two wheels on either side being placed in tandem with their axles carried in a bridge-like truss of heavy construction. This carries the shock-absorber cord at its middle, which enables the outer struts directly under the wing-strut to be rigidly connected to the horizontal cross-struts of the chassis and the inclined struts going to the central fuselage. The chassis is built up of steel tubing faired in. While it looks very rugged, it cannot be said that it is as clean as other twin-engine designs. The disposition of the wheel and tandem should be of considerable help in preventing nosing over of the machine.

The interior of the fuselage is very nicely arranged. For the large useful load of the Eagle, the moderate horse power of 450 may be said to be very economical. The span of 61 ft., the length of 37 ft. and the height of 12 ft. 4 in. may be considered as very moderate for its dimensions. An interesting feature of the Curtiss exhibit is presented by a beautiful small scale of the Curtiss wind-tunnel, which seemed to attract the attention of even the uninitiated public.

Curtiss Oriole

The Curtiss Oriole seems to be one of the most logical three-seater ships exhibited at the Show. The pilot has a reasonable position far back where he has uninterrupted vision and a good sense of control. The passengers in front of him share a fairly roomy cockpit provided with an efficient wind-shield. The streamline of the veneer fuselage is very good, and its construction is similar to that of the Eagle. The engine is well streamlined in such parts as project above the fuselage, being all the better for extra cooling. The engine is readily accessible. Equipped with 150 hp. the machine has ample performance, and a fairly low landing speed. It may be considered as a well finished and well balanced design.

Dayton-Wright Planes

The Dayton-Wright Co. exhibit two land machines of the enclosed or limousine type. One is the O. W., for which full specifications have been given in the Jan. 1st issue of AVIATION. This machine provides a very comfortably equipped limousine, for the pilot and passengers, but it embodies some features open to criticism.

The provision of an enormous hump body seems somewhat of a handicap on a machine provided with only a 180 hp. engine. Nevertheless a maximum speed of 85 m.p.h. has actually been obtained in flight, and the landing speed with a loading of 4.66 lb. per sq. ft. is very low. It is still a mooted point whether even in the purely commercial plane, such a low wing loading is advantageous. This detracts from the high speed and decreases the maneuverability, while at the same time on a gusty day the machine which has a low wing loading is more likely to be thrown about in the air than the heavily loaded machine. The visibility of the plane is quite good, provided rain does not impede vision through the windows.

It should be noted that owing to the large free space left in the fuselage, no cross bracing is provided, and no bulk-heads are in evidence. It is not apparent although the veneer sides of the fuselage are connected to a solid center wing panel, whether structural safety has been sufficiently provided for. It is noticeable that on this machine no vertical fin area is provided, particularly as the forward part of the fuselage presents so much lateral area. Enclosed fuselages with no cross bracing is a departure in design which will be watched with great interest. Hard wire has been employed on both the flying and landing wires of the wing truss. A window cleaner is provided for the windows.

The propeller offers an interesting innovation. Instead of the usual hub, a large round wooden spinner is provided which is an integral part of the hub. The propeller blade is composed of double cambered elements throughout, and the plan form narrows down gradually toward the tips. The pitch is very low and while the high speed is not improved thereby, this peculiar design of propeller enables the r.p.m. at climb to be well maintained. It is also probable that efficiency of the propeller is maintained through a larger range owing to the double cambered sections. The propeller is said to have no flapping tendencies whatsoever.

A peculiar feature of the design is the air cooling of the exhaust manifolds by means of an outer tube, which has suction at its extreme end. This seems to be a very desirable feature. While no shutter is provided for the radiator, there is an adjustable air opening in the engine section, which permits of air flow regulation in a very simple manner. The radiator is very large for the size of the engine employed. It is an interesting feature of the Dayton-Wright sales policy, the machine is on sale as a custom-made machine, which can be altered to suit the desire of every purchaser.

The Dayton-Wright K.T. 1 is likewise a totally enclosed machine, equipped with a Liberty 12-cyl. engine. This machine is more or less of standard design, and seems very well carried out, adjustable ventilation being provided for the interior of the limousine. A wing radiator is used. The enormous six-hour cruising radius tank can be readily removed by just removing the radiator. The fore and aft wires at the center section are carried outside the fuselage, attached directly to the wing. This helps to keep the cowling intact upon removal of the tank. The controls are concealed and a spare wheel is carried inside the fuselage. Altogether this would appear to be a very workmanlike job. The fuselage is a heavy veneer construction with an incomplete side-truss of wood.

Avro Three-Seater

Outside of the Curtiss Oriole and American and Canadian JN planes—which latter still retain their hold on the public through their long and useful career—the only small land machine at the Show was the Avro 504-M three-place biplane, which was exhibited by the Interallied Aircraft Corp.

Although primarily designed for training, in which capacity it has been used as the standard plane of the Royal Air Force, the Avro 504-M has a great many possibilities for commercial purposes. There is good vision, ease of control and a sturdy engine mounting, with the engine, a 110 hp. Le Rhone rotary, readily accessible for inspection. The seating of the two passengers in tandem is perhaps not as comfortable as the side by side arrangement, but altogether the Avro 504-M has a very pleasing appearance.

The most notable constructional feature, because it marks a departure from accepted American practice, is presented by the landing gear skid. This is solidly braced and answers the purpose of preventing nosing over on a rough landing, while its rear end exerts a powerful braking action. This seems a valuable feature.

The high speed, given as 90 m.p.h., is apparently an official record.

Goodyear Pony Blimp

The Goodyear Co. had a very comprehensive exhibit of lighter-than-air craft, showing a number of models of former constructions and details of its folding air scoop for airships. Its most interesting exhibit, however, was the type A airship, designated as "Pony Blimp," which is described in detail elsewhere in this issue.

This is a non-rigid airship of 35,000 cu. ft. capacity, 95 ft. length, 28 ft. diameter and 40 ft. overall height. It is undoubtedly the smallest craft of its kind in existence and is particularly interesting in that it represents the smallest size practicable for the carrying of two persons. Fitted with an Ace 40 hp. engine, the ship has a high speed of 40 m.p.h. and a full speed endurance of 10 hr. The disposable lift (crew, fuel and ballast) is 800 lb.

The envelope is notable for its extremely reduced fineness ratio, 3.3 to 1, which marks a decided departure from contemporary design, but which is entirely justifiable where, as in this case, great compactness, simplicity in rigging and the possibility of using the airship as a free balloon are desired.

The car, which is like the envelope beautifully streamlined, is a mahogany veneer construction, semi-monocoque type, being built up of bulkheads and veneer planking, which insures great strength and lightness. It seats comfortably two persons. Single control is provided with a sliding wheel for altitude steering which permits the pilot to control with either right or left hand, or in the center, as he may desire. Directional control is by means of a foot bar. The car is completely equipped with instruments for cross country navigation.

At the rear end of the car a strong skid affords protection on landing and this can be fitted with a single pontoon for alighting on the sea.

An innovation of value in cross country flying is the demountable feature of the Pony Blimp. By the simple removal of a few pins the car and control planes may be unshipped and the envelope may then be bagged down to the ground. The ship is also equipped with a mooring harness which permits its being moored and allowed to ride in the air as a captive balloon.

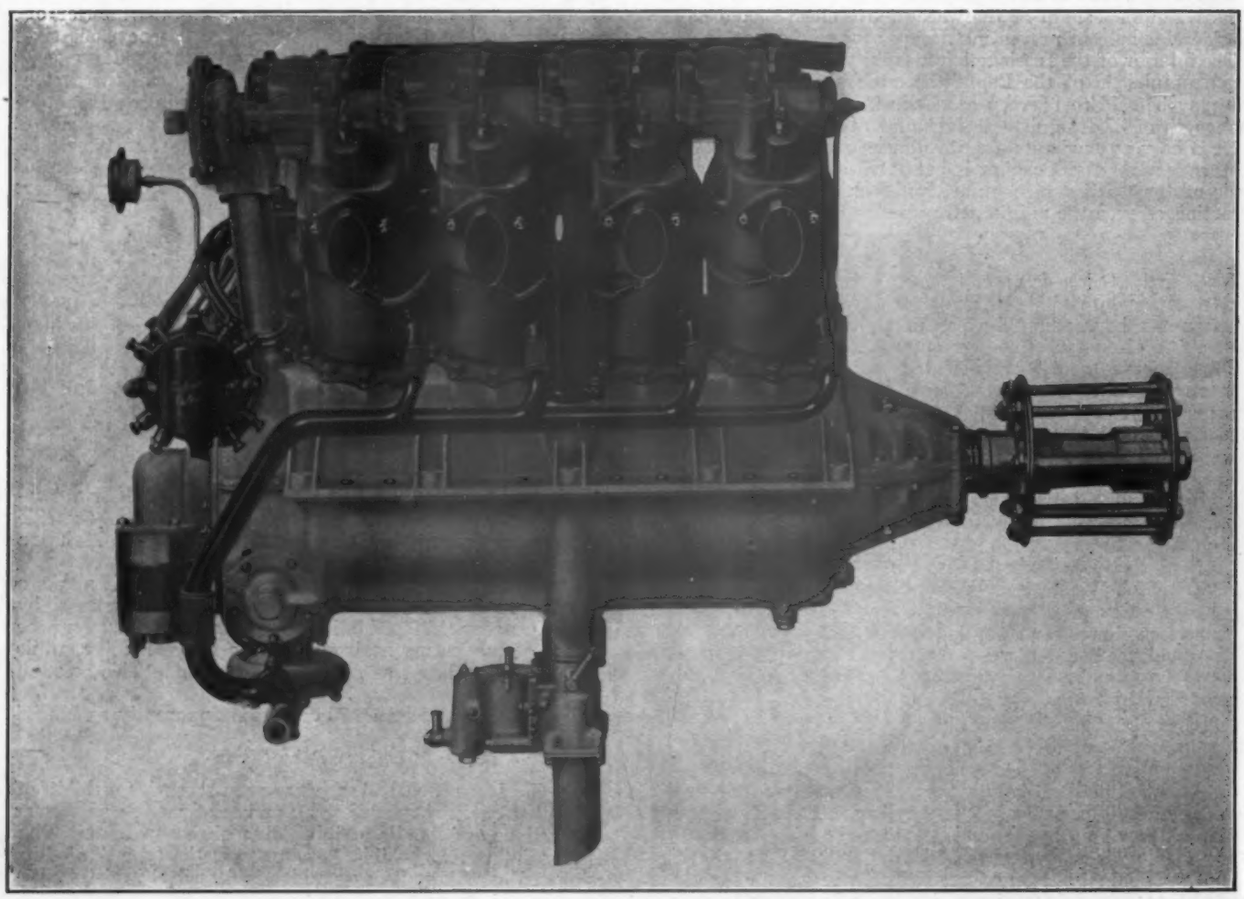
From the standpoint of the government this little ship will probably open up a new development in naval operations insofar as it can be towed from a warship like a kite balloon and cut loose when desired. It would thus add the important factor of mobility to the observation advantages possessed by kite balloons. From a commercial standpoint the Pony Blimp will undoubtedly appeal to many sportsmen or flying clubs, as its operation and maintenance is not too expensive for private or club use, while its sporting value is of a high order.

Engine Exhibits

Exhibits of aircraft engines were comparatively few in number at the Chicago Show. Besides the Curtiss Six 150 hp. vertical water-cooled engine, the performance of which is most excellently illustrated by the long flights of the Oriole and the Eagle, exhibits included Hispano-Suiza 180 and 300 hp. models and two new Packard engines. The war and peace record of the Hispano-Suiza engines is too well known to require mentioning; it may, however, be noted that henceforth the American-built Hispano-Suiza engines, produced by the Wright Aeronautical Corp. of New Brunswick, N. J., will be known under the name of Wright-Hispano to indicate the important improvements this firm and its predecessor the Wright-Martin Aircraft Corp. have embodied in this design.

The Packard exhibit comprised two interesting engines specially adapted for commercial use. One, the model 1-A-744, is an 8-cyl. water-cooled type, with the cylinders set at a 60-deg. angle, an innovation in 8-cyl. engine design which has the advantage of reducing cross dimensions. The engine is of a somewhat sturdier construction than the average run, which tends to increase its endurance in commercial usage. For a maximum output of 200 hp. at 1,850 r.p.m. the total weight dry is 560 lb. Bore is 4¾ in., stroke 5¼ in. and cubic displacement 744 cu. in.

The great feature of this engine is its wonderful accessibility. The carburetor being placed underneath the engine it is extremely accessible and fire hazard is to a large extent eliminated. The distributor heads are placed parallel to the axis of the machine, so that with a small door in the cowling they permit easy inspection. The same remark applies to the water-pump and the oil-pump. The projected area of the engine is not too large for its power, and the job should be



SIDE VIEW OF THE PACKARD 1-A-744 8-CYL. 170 HP. ENGINE

very interesting for commercial usage, and its further production will be watched with interest. The engine is a low compression one, with flat pistons. By changing the piston, high compression and more power could be very readily employed in the same engine, ample margin of safety existing for this purpose.

The other Packard engine, model 1-A-1116, is almost identical in design with the 8-cyl. model, except that it has twelve cylinders and a cubic displacement of 1116 cu. in. The power output is 300 hp. at 1,850 r.p.m. Most parts are interchangeable between the two engines.

The Aeromarine Co. exhibited its well-known L-6D vertical 6-cyl. water-cooled engine.

Some foreign engines, a Salmson, a Green and one or two others, were exhibited by the U. S. Navy.

McCook Field and the Airplane Industry

In AVIATION AND AERONAUTICAL ENGINEERING *for Nov. 15, 1919, there appeared an editorial which criticized the policy of the Airplane Engineering Department of the Air Service, at McCook Field, Dayton, Ohio, for its relations with the airplane industry. The following statement, which has been received from a reliable authority, expresses the views of McCook Field in this matter, and will therefore be of interest to American airplane designers and constructors.*

A somewhat superficial investigation of the present conditions controlling ways and means for the development of military airplanes for the United States Army indicates a lack of sympathy between the civilian designers and constructors, and the officials at the Airplane Engineering Division at McCook Field. If this condition is real, it is much to be deplored, for, until these two factions, each indispensable for the perfection of design of military equipment, come to work in hearty sympathy and understanding, development cannot go forward at its proper rate.

It seems quite possible that the evident lack of sympathy may be due largely to failure of each to get the other's viewpoint, which may, in turn, result from the geographical separation of the two activities. McCook Field is in Ohio, while a large part of the present airplane industry is concentrated around New York City—on the extreme eastern edge of a country 3000 miles wide. Consequently, the McCook Field officials do not see enough of the activities of the civilian experts—do not talk to them often enough to learn their many problems, or to get first hand their point of view. On the other hand, it is probable that the civilians of the industry do not keep themselves intimately posted regarding the work at McCook Field, and may even at times condemn this institution for its methods without really knowing the conditions under which it labors and which make its task a very complicated one.

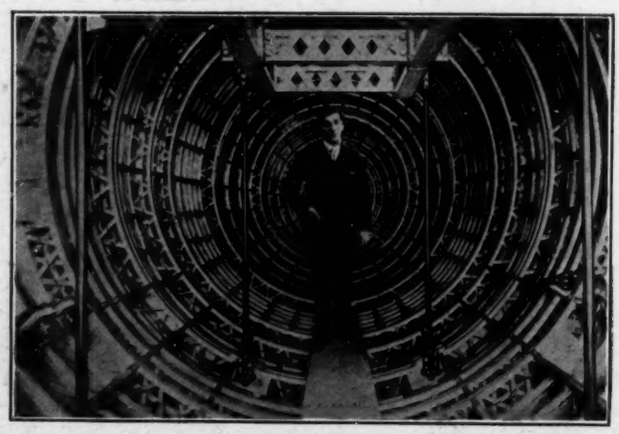
It may help to mention a few of the points of apparent difference. The Engineering Division is charged with providing the Air Service with satisfactory types of airplanes for the performance of certain military functions. No remarks are needed as to the complexity of the airplane as a complete military unit. The Engineering Division feels that civilian designers have sacrificed ease of production and maintenance for performance. In general, it is true that experimental airplanes delivered to McCook Field are unsatisfactory for military purposes without extensive alterations. Perhaps the Engineering Division is at fault in not getting clearly before civilian engineers the relative importance of ease of production, maintenance and performance. The usual aim for a military airplane in the civilian industry is super-performance, while the military aim is a proper vehicle for transporting the diversified military equipment required, and doing this in a manner to make the composite result an apparatus of easy maintenance in the field and with as good a performance as it is possible to obtain.

American civilian designers are perfectly capable of designing excellent airplanes, but the experience of Army engineers is that the only way they can design military airplanes is by keeping constantly in touch with the development, not only of the military weapons and instruments themselves, but also the method of operating them in actual warfare, which, of course, determines location and methods and arrangements of installation. The officials at McCook Field appreciate fully the fact that the greatest hope for our supremacy in the air lies in the inherent ingenuity of Americans in general and not in the work of a few men in the Government employ. These same officials, however, feel that some of our civilian designers fail to keep in touch with the development of military instruments and the uses to which military airplanes are put, and are, therefore, not fully qualified to build military airplanes. McCook Field must necessarily undertake the solution of hundreds of widely diversified engineering and scientific problems, many of which appear small and are not appreciated by the casual observer, which, while not interesting for commercial airplanes, are the things which make military airplanes effective in performing their highly specialized functions. A great amount of research is also done in connection with the details and methods of design.

The officials at McCook Field believe, first, that independent civilian designers should be encouraged when their work is of such quality to warrant it, both financially and by close cooperation and assistance; second, that McCook Field is in a much better position to know intimately the requirements touching on military airplanes and equipment than any independent designer; third, that, as McCook Field is required to pass on airplanes submitted by outside designers and to correct defects in these airplanes after they are placed in service, McCook Field must know intimately the problems and difficulties of design, and it is maintained at McCook Field that these things can only be learned by actually designing and building, in a limited way, airplanes; fourth, that McCook Field should build up and educate an organization capable of designing military airplanes as a safeguard to the Government against the future, when independent civilian designers may turn from work on military types to the more certain and lucrative task of designing commercial airplanes and airships.

During the past year McCook Field has been seriously handicapped with its intercourse with outside designers by three things: first, the necessity of returning to the pre-war-time method of advertising for bids and conforming to the other multitudinous regulations covering Government contracts; second, shortage of funds, the appropriations allowed for airplane engineering being entirely too small to keep all outside engineering facilities busy; third, certain difficulties experienced in getting authority to print and distribute technical information intended for use of designers and manufacturers, which prevented McCook Field from getting information to designers as promptly as it would have liked. Some of these difficulties have been overcome, and the monthly publication, "Technical Orders," is again being distributed through the Information Group, Washington.

McCook Field is willing and anxious at any time to receive suggestions in the way of designs from all civilian concerns interested. The shortage of funds, however, will prevent the letting of many experimental contracts, as the multitudinous small work mentioned above and the corrections and defects of existing types must go on. It is believed that all unite in hoping that Congressional appropriations for the next fiscal year will be more liberal, so more work can be done by independent designers.



FUSELAGE OF THE ENGLISH TARRANT TRIPLANE
Photo International

The Aeromarine Model 40 Flying Boat

By Paul G. Zimmermann

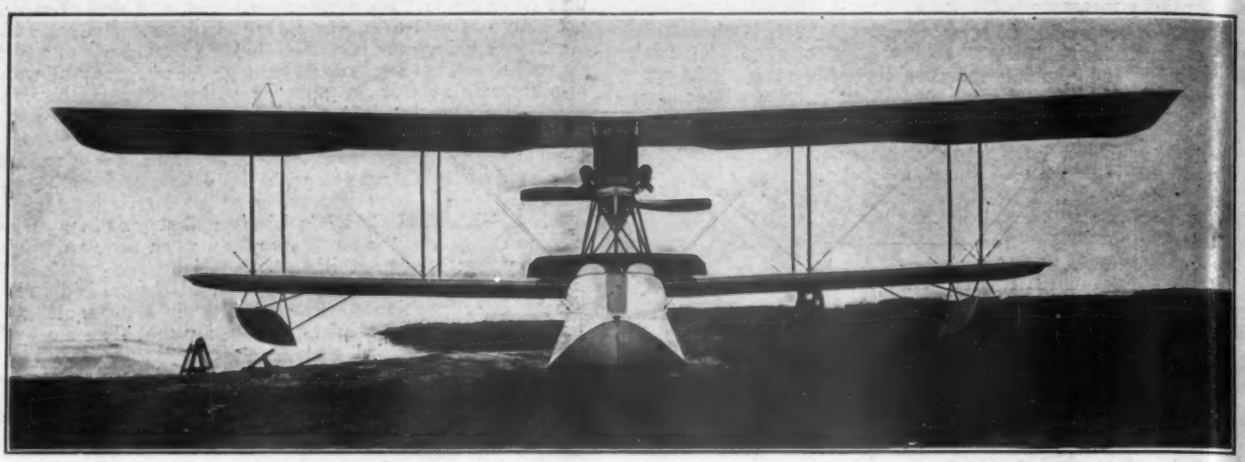


FIG. 1. AEROMARINE MODEL 40 FLYING BOAT, AEROMARINE B-8 ENGINE

The great cruising ability of huge multi-motored flying boats was demonstrated to a skeptical world when the NC-4 winged her rapid way to Europe. This proved beyond doubt that nations might send their aircraft long distances and repair and re-fuel them from surface vessels. It was not, however, illuminating concerning the mobility of small flying boats, two or three passenger machines with a single motor, such as are now beginning to be used commercially and for sport purposes.

A most exacting test of the touring qualities of this small type of modern ship was made recently by the Aeromarine Plane & Motor Co., of Keyport, N. J. This company dispatched an Aeromarine model 40 flying boat (see Fig. 1) from New York on a long distance tour down the coast to Key West, thence to Havana, and back to Keyport by the same route. No special stations for repair or overhauling were established, for it was the intention of the company that the plane should make the trip under precisely the same conditions as would confront an amateur flier making the trip for sport or business reasons.

Besides the flying boat itself, two types of Aeromarine motors were tested out under service conditions. The B-8, an eight cylinder, 90 deg. V motor was used as far as Key West, and the flight to Havana and the return trip northward was made with an "L-6D." This latter is a direct drive, six cylinder aluminum block motor with a removable head. The camshaft and valves are located in the head. Both motors are of 130 hp.

While en route the plane used ordinary gasoline and oil from automobile or motor boat stations, and on one occasion alighted on the ocean near St. Augustine, Fla., borrowed a gallon of oil from an astounded motor boat crew, and went on with motor purring contentedly.

The plane was piloted by C. J. Zimmermann, chief test pilot for the Aeromarine company. He was accompanied by Richard Greisinger, mechanic. Aero, a bull pup, also went along, and proved worth more than his weight in gasoline as a mascot.

The trip began on Oct. 27 and ended on Dec. 3, 1919. A stop of more than two weeks was made at Key West for the purpose of changing motors and to inaugurate the first air line between Havana and Key West. This service was started by a Cuban-American company with Aeromarine flying boats.

There was no intention of establishing a record for the trip either in flying or elapsed time, for the primary design of the trip was exactly to reproduce normal aerial touring conditions. Unusually bad fogs were encountered on several occasions, and stop overs were made because of this. The start from Keyport was delayed two hours because of fog, but as soon as it had lifted slightly Pilot Zimmermann hopped off and succeeded in flying through the mist to Atlantic City, the first scheduled stopping point. Twice he was driven to the surface of the ocean to get his bearings.

Flying down the Atlantic coast would seem on first thought to be a very easy matter, but as a matter of fact, aerial navigation, which differs somewhat from marine, was necessary. An ingenious roller chart, with lighthouses, life-saving stations,

FIG. 2. AEROMARINE MODEL 40 FLYING BOAT, AEROMARINE L-6D ENGINE

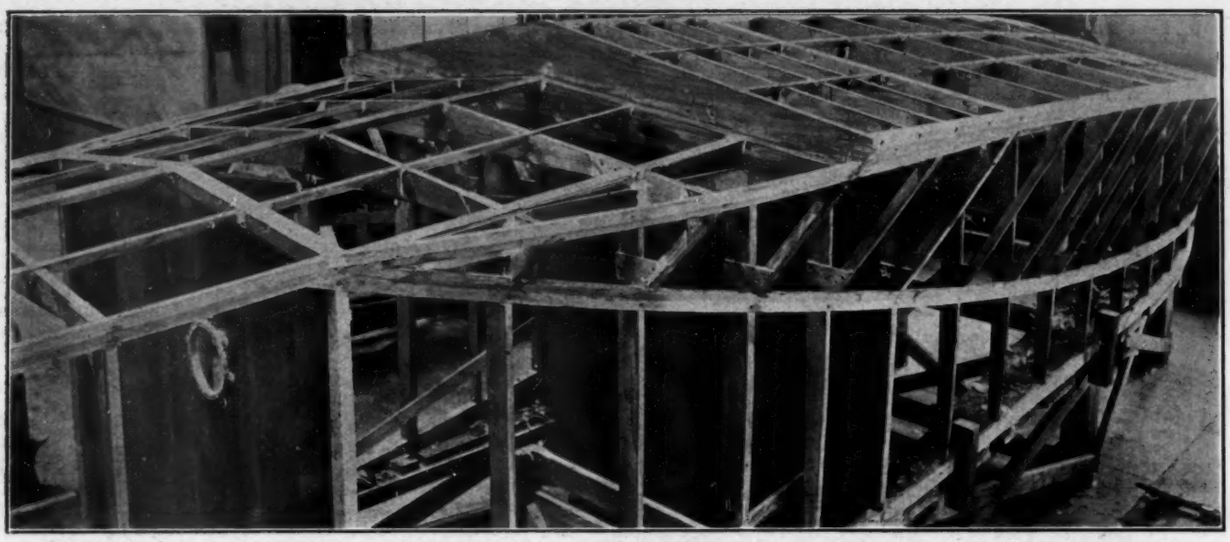


FIG. 3. CONSTRUCTION OF AEROMARINE BOAT HULL AT STEP

buoys and other landmarks plainly indicated, was used. The map was of the strip type. Wherever the curving coast line tended to stray off the chart the bend was straightened out on the map and a new compass course marked at the juncture. The map was mounted in a narrow box with a roller on each end. The front of the box was covered with sheet celluloid so that the map itself was screened from wind and water. The pilot could follow his course simply by turning one of the rollers. The distance from the starting point of the various life saving stations was noted on the map so that the pilot could keep accurately informed of his location at every stage of the flight.

As the plane carried gasoline for about three hours' flight, stops were made at distances of 200 mi. or less. The longest distance flown in a day was 610 mi., from Manteo, N. C., to St. Augustine, Fla. Flying time southward was 24 hr. and 45 min. The return journey, which was hampered by bad weather and unusually strong head winds, was made in 26 hr. in the air.

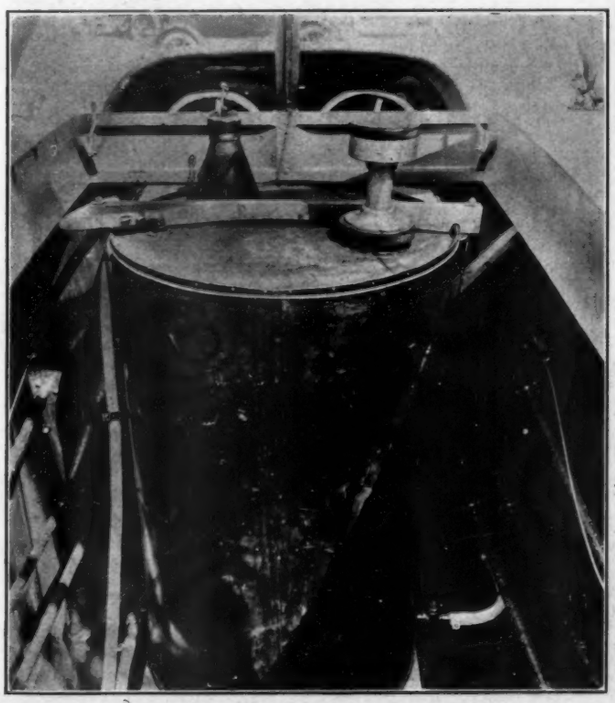


FIG. 4. GASOLINE COMPARTMENT OF THE AEROMARINE MODEL 40

General Description

The boat which made the flight is a pusher biplane of unusually sturdy construction. The pilot and mechanic sit in the hull just in front of the forward wing beam at a dual wheel control. The designers of the ship aimed particularly at strength and finished appearance in the general construction.

Upon closer examination these qualities are found to be carried out in the detail design. Four steel tube braces with

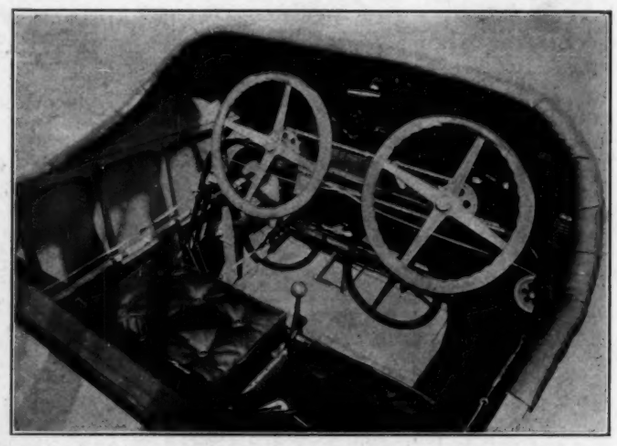


FIG. 5. COCKPIT OF THE AEROMARINE MODEL 40

neatly flattened and reinforced ends form the main supports for the motor, which is bolted to spruce laminated beds, faced top and bottom with ash. The flattened ends of these tubes project past the upper faces of the engine beds and form the attachment for the tubing upper panel supports. Transversely the beds are braced in the plane of supports, front and rear by cross tubes attached at the top and bottom to the same bolts as the supports.

At the top a separate sheet steel engine bed saddle joins the cross tubes and main supports. Two diagonal steel tube braces connect the upper ends of the rear supports to the front lower beam clips, which in turn are braced to the forward front floors by heavy spruce braces, thus affording ample protection against motor crushing forward on a bad landing.

The motor is connected directly to a pusher propeller. Clearance for the propeller is cut out of the upper panel, the panel edge being carefully streamlined at this point.

A T-shaped honeycomb radiator with an extra large water

tank at the top, directly in back of the front upper panel struts and attached to the engine beds by hinge joints, cools the motor.

A gravity gasoline tank of 5 gal. capacity and an oil tank are located in the center section panel directly over the motor. Tubes connected to these tanks are led down the front and rear struts. Titeflex tubing is employed for all oil connections, while rubber is used for gasoline.

Motor controls, instrument lines, and the various supply tubes are led through a hollow centrally located metal streamline, specially provided for the purpose, to the hull. This

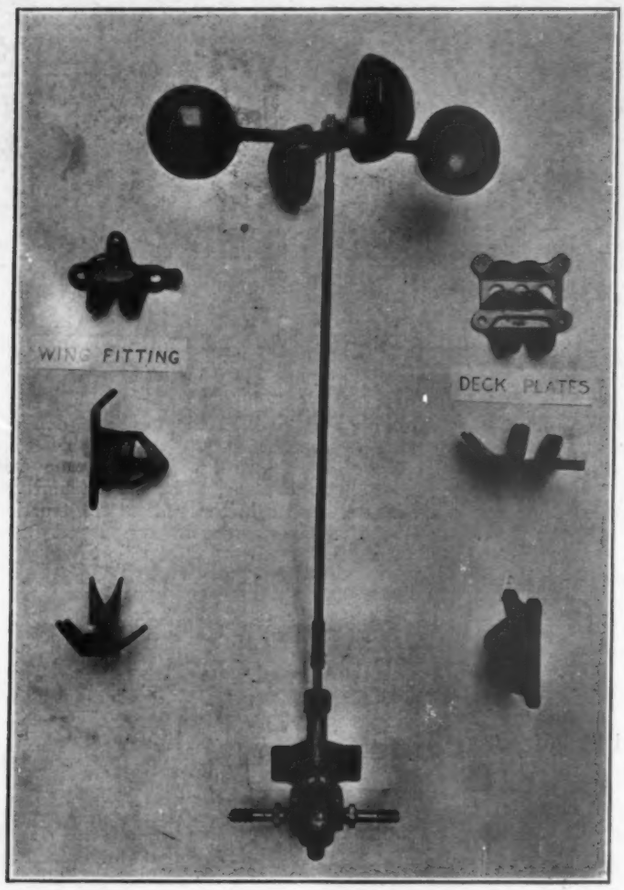


FIG. 6. ANEMOMETER AND PRINCIPAL FITTINGS OF THE AEROMARINE MODEL 40

makes them at all times readily accessible. The spark control, choke, and starting switch are attached to the engine beds.

The hull is of the attached tail type, built up of spruce frames spaced from 9 in. in the front to 12 in. at the tail. Auxiliary ribs are inserted directly in front of the step, reducing the spacing at the bottom forward of the step to four and a half inches (see Fig. 3).

Five watertight compartments are separated by reinforced veneer bulkheads. Handhole covers are provided to make these accessible for bailing. The bulkheads at the front and rear beams and eight steel straps serve as the attachments by which the hull is lifted. The siding and top are of $\frac{1}{8}$ in. three ply waterproof veneer and the forward bottom two $\frac{3}{16}$ in. diagonal laminations of Port Orford cedar with cloth and marine glue between them. The after bottom is of the same material and construction, but each lamination is $\frac{1}{8}$ in. thick. A $\frac{3}{16}$ in. flooring is located under the pilot's seat forward to the first bulkhead.

The main gasoline tank, which is cylindrical, rests upright on a stand to the rear of and against the front bulkhead (Fig. 4). It is tied securely to the floor by $\frac{1}{8}$-in. steel tie rods and to the bulkhead by a cable and turnbuckle.

The seat bottom is attached to the seat rails, held securely to the side of the boat. The back is removable to allow access to an 18-in. compartment to the rear of the pilot's seat. Navy type safety belts are provided. The horizontal strap is attached to the bulkhead, while the vertical passes around the seat rail.

An instrument board with the usual instruments is placed just ahead of the steel tube bridge dual control. Individual windshields are attached on either side of the front cowl directly in front of the pilot's seat.

The front cowl is removable, allowing access to the forward portion of the boat. In case of a bad landing this cover breaks loose, saving the pilot from the danger of being crushed by it.

Two foot bars connected in the rear by a tube are supported by built-up sheet steel pivots. The rudder wires are attached directly to the ends of these bars, and adjustment in length is provided. All control wires are led through the hull by means of $\frac{3}{4}$-in. brass tubing, which is large enough to allow a shackle to be drawn through it, thus allowing an inspection of the wires as occasion demands. The aileron control cables are carried over pulleys at the rear of the rear beams and thence through guides and a pulley directly to the lower side of the aileron beam.

The wings are attached to the hull by vertical wing hinges. The main lift wires attach directly to the hull beam fitting. The panels are of standard construction with spruce I section beams, pine webs reinforced with fibre strips and spruce capstrips. The leading and trailing edges are of spruce. The covering is the best quality airplane fabric, doped and either varnished or painted.

The tail unit is of wood construction, excepting the rudder, which has a steel tube frame and the elevator trailing edge, which is of steel tubing flattened to streamline form.

An anemometer-driven gear pump, located so that the anemometer swings half in the hull, lifts the gasoline from the main to the gravity tank, and an auxiliary hand pump is located on the dash in easy reach of the pilot.

Characteristics of the Model 40 flying boat are as follows:

Type of Machine	Pusher Flying Boat.
Overall Height	12 ft. 7 in.
Overall Length	28 ft. 11-3/16 in.
Weight (Full Load)	2772 lb.
Weight (Light Load)	2161 lb.
Span	48 ft. 6 in.
Total Area	504 sq. ft.
Wing Curve	R.A.F. 6.
Upper Wing	
Span	48 ft. 6 in.
Area	304 sq. ft.
Chord	6 ft. 3 in.
Angle of Incidence	3 deg. 5 min.
Dihedral Angle	176 deg. 0 min.
Lower Wing	
Span	37 ft. 8 in.
Area	200 sq. ft.
Chord	6 ft. 3 in.
Angle of Incidence	2 deg. 0 min.
Dihedral Angle	176 deg. 0 min.
Stagger	8 in.
Gap	6 ft. 6 in.
Sweepback	None
Decalage	1 deg. 30 min.
Area of Ailerons (2)	58 sq. ft.
Area of Elevators (2)	25.6 sq. ft.
Area of Rudder	17.5 sq. ft.
Area of Stabilizer	39 sq. ft.
Area of Fin	15 sq. ft.
Skid Fins	None
Engine	Aeromarine B-8 or L-6D
Horsepower	130
Propeller	Aeromarine 8ft.2in.x4ft.
Tank Capacity	40 gal.
Fuel Consumption, b.h.p. hr.	0.55 lb.
Load per sq. ft. of area	5.50 lb.
Load in h.p.	21.30 lb.
Maximum Speed	72 m.p.h.
Minimum Speed	47.5 m.p.h.
Rate of Climb (in ten minutes	2600 ft.
Endurance in hours	4.3 hr.

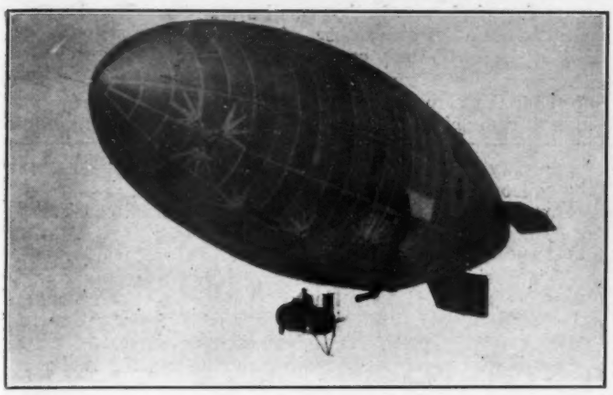
Seaplane Float Construction

Persons concerned with the construction of seaplane floats will be interested to learn that the article, Seaplane Float Construction, by Charles C. MacGregor, which appeared in serial form in early issues of AVIATION AND AERONAUTICAL ENGINEERING, now out of print, has been reprinted in pamphlet form by L. W. Ferdinand and Co., the well known manufacturers of Jeffery's Marine Glue. The booklet deals very exhaustively with the generally approved construction of seaplane floats and is profusely illustrated; its value for seaplane designers is therefore obvious. The booklet may be had upon application from L. W. Ferdinand and Co., 152 Kneeland St., Boston, Mass.

The Goodyear Type A Pony Blimp

The Goodyear type A airship, or Pony Blimp, has been designed to fill the popular requirements for a lighter-than-air craft usable for sporting and commercial purposes, and for special naval use as a substitute for kite balloons.

The Pony Blimp is non-rigid, with external rigging in the form of finger patches, which support a single streamlined car. Propulsion is effected by means of an Ace 40 hp., water-cooled engine driving a pusher airscrew. The principal dimensions and the designed performance of the ship are as follows:



THREE-QUARTER FRONT VIEW OF THE GOODYEAR PONY BLIMP

CHARACTERISTICS

Volume	35,000 cu. ft.
Ballonet	7,000 cu. ft.
Length	95 ft.
Maximum diameter	28 ft.
Maximum width	29 ft.
Height	40 ft.
Vertical fins and rudder	160 sq. ft.
Horizontal fins and elevators	194 sq. ft.
Length of car	12 ft.
Width of car	2½ ft.
Crew	2
Power plant—Ace—or equivalent	40 hp.
Maximum speed	40 m.p.h.
Fuel supply at full speed	10 hr.
Range at full speed	400 m.
Ceiling	6,000 ft.
Useful load available for crew, fuel and ballast	800 lb.

Lift—The useful lift as measured on trials was 935 lb., including passengers, ballast, anchor, drag rope, parachutes and fuel. Barometer 28.7 in., temperature — 3 deg. Cent., gas purity 98.5 per cent, envelope pressure 1 in.

Under assumed worst conditions at sea level of 95 deg. Fahr. and 97 per cent purity (or 85 deg. Fahr. and 95 per cent purity) it would have a net lift of approximately 700 lb. This would be enough for one man and full fuel or two men and half fuel, with still plenty of reserve for a light wireless set. A small overload, up to 50 lb., can be carried dynamically without particular difficulty, providing it is in readily dispensable form. Besides the useful load proper as above listed, there is some 40 lb. of water in the radiator and about 20 lb. of other material which could be used as ballast in an emergency.

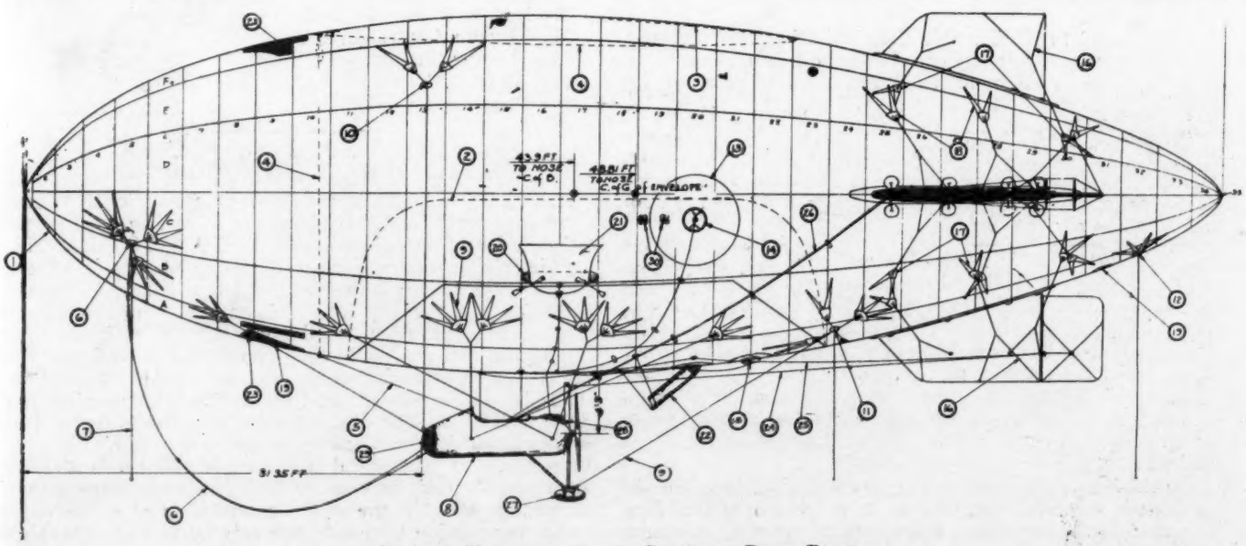
Operating—In the trials the ship handled very easily and conveniently, there being no appreciable troubles developed. The quick maneuvering qualities were particularly noticeable, it being possible to make sharp turns. An angle of ascent of 42 deg. was obtained, and an angle of descent of 35 deg.

CAR OF THE PONY BLIMP. NOTE MOUNTING OF RADIATOR AND OF AIR SCOOP

Landing the ship was exceptionally easy, it being handled on one occasion, in a light breeze, by a ground crew of only two men.

An instruction book for this ship is in preparation.

Speed and Efficiency—The speed actually covered over a measured course in two directions averaged 37½ m.p.h. in a light but gusty cross wind. Estimating from the pressure at which the nose caved in, the air speed indicated slightly over 40 m.p.h. This was with full flight equipment, including para-



OUTLINE DRAWING OF THE GOODYEAR PONY BLIMP

chutes. The propeller actually used was designed to obtain maximum speed. It will be possible, however, to get somewhat better efficiency and fuel economy with very little sacrifice in speed by using a larger propeller at slower r.p.m.

The wind tunnel tests on the envelope shape were conducted at the new Curtiss tunnel at Garden City.

Power Plant—The 40 hp. Ace engine (modified for airship use) consumed approximately 24 lb. (nearly 4 gal.) of fuel per hour when running full out (about 2000 r.p.m.). It throttles down nicely and runs with very little vibration. The radi-

POWER PLANT OF THE PONY BLIMP. NOTE POSITION OF EXHAUST PIPES

ator was found to be of ample size, indicating that it would cool the engine satisfactorily even in the hottest weather. The mounting of the radiator at the extreme rear adjacent to the propeller gives sufficient suction to cool the engine even in a static test. This position of the radiator does not cause any vibration. No trouble with starting has been experienced at any time.

The two fuel tanks on each side of the envelope hold a total of 40 gal. There is a large release valve on one side only which will in a few seconds discharge any or all of the gasoline in that tank. After a few minutes have elapsed enough gasoline will flow through from the other tank to serve again as ballast. In this way half of the total amount of fuel on hand can always be quickly discharged if necessary.

The tanks are filled by a simple connection in the car without any necessity for climbing up to them.

Towing—The ship can be used as a kite balloon by allowing it to ride on the end of the drag rope. In case it is wished to bag the ship down in the open, it is only necessary to remove the lower fin, car, scoop and air valve.

Use As Free Balloon—The comparatively fat shape for the envelope is somewhat less efficient than the shapes that have been used for larger ships. It was selected partly on account of its general compactness, simplicity and the possibility of saving weight, but more specially on account of its free ballooning qualities.

There is no claim that this little airship can be landed entirely without damage like a free balloon, as there is always likelihood of small breakages in the fins and car, but there is every reason to believe that these would be less than with any ordinary size airship. With the new development in anchors there would seem no longer any reason for making a forced landing with no other aid than the rip panel.

Car—This is a wood veneer construction, light but substantial, holding normally two persons, but wide enough to accommodate a third passenger in the rear seat. There is plenty of space for wireless and other small apparatus. The drag rope is carried in a box in the nose. A small pontoon bumper which fits the single skid may be carried or not, as desired.

Accessories—A small size harpoon anchor has been developed for this ship on the same principle as has been successful in larger airships. A new design of fuel pump is used for pumping gasoline from the car up to the tanks. The same pump may be used for pumping fuel up a hose when towing the balloon.

For oversea use a sea anchor is recommended consisting of one flexible unit of the standard Goodyear design. A rubber shock-absorber is used with either a sea or land anchor.

This airship is no sense a toy. Although no larger than a medium size spherical and not as large as a standard type R kite balloon, this little airship carries a power plant large enough and efficient means of control to give it perfect freedom of motion in any ordinary wind, and in cruising radius it is in a class with ships many times its size.

The legend of the numbers occurring on the outline drawing is as follows:

1—Envelope
2—Ballonet
3—Rip Panel
4—Rip Panel Cord (inside of bag)
5—Rip Panel Cord (outside of bag)
6—Nose Mooring Line Unit
7—Nose Grab Lines
8—Two-passenger Car
9—Car Suspension
10—Side Grab Line Unit
11—Center Grab Line Unit
12—Rear Grab Line Unit
13 and 14—18-in Gas Valve
15—18-in. Air Valve
16—Fin Brace Wires
17 and 18—Fin Brace Patches
19—Inflation Sleeve and Cover
20—Gasoline Tank
21—Gasoline Tank Sling
22—Air Scoop
23—License Number
24—Rudder Control Line
25—Rudder Emergency Line
26—Elevator Control Line
27—Landing Bumper
28—Motor, 4-Cyl.—40 HP.
29—Drag Rope

Radio Marker for Aerodromes

According to the fifth anual report of the National Advisory Committee for Aeronautics, just issued, the Bureau of Standards has developed, primarily for the Air Mail Service, a field-marking radio device which enables a pilot to steer directly to the center of his landing field, although it may be obscured by clouds, rain, snow or fog. This apparatus utilizes the same transmitting equipment for the ordinary radio direction-finding signals and for the landing signals. The landing signals are projected vertically as an electro-magnetic cone of great intensity, which can be heard satisfactorily at an altitude of 3000 or 4000 ft. The device enables the pilot to first find the approximate vicinity of a landing field and then fly directly to its center, thus making a safe landing in a fog or in the dark. As elevated aerial systems are manifestly dangerous to air navigation, the Air Mail Service experimented extensively in radio transmission with antennae only 20 ft. in height, highly directional, and admitting of sharp tuning.

Orenco Military Airplanes

ORENCO PURSUIT AIRPLANE TYPE B, 160 HP. GNOME

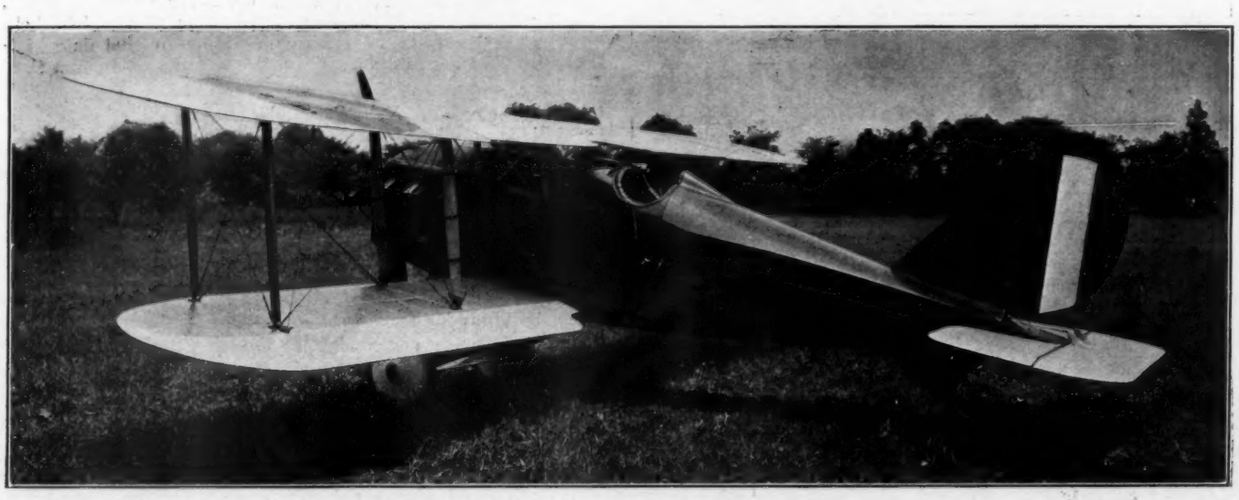
During the war the Ordnance Engineering Corporation, builders of Orenco airplanes, were constantly in close touch with the military authorities engaged in developing up-to-date training and fighting aircraft for the rapidly increasing air service. The first Orenco plane, the type A, was a two-seater primary training tractor with dual control and side-by-side seating. Students were trained in less time than when the tandem type plane was used, for it was possible for the pupil to observe the actual movements of the pilot in bringing about the various attitudes of flight.

The type B pursuit fighter, a fast plane designed to carry a novel arrangement of experimental machine guns, was one of the fastest planes of its kind. With a 160 hp. Gnome engine the speed was 135 m.p.h. Urgent need for advanced training planes led to the conversion of this plane to a training machine, called type C. This plane with an 80 hp. Le Rhone engine was identical in all other respects to the type B and its performances were no less remarkable. Its high speed was 102 m.p.h. and the landing speed, which was of considerable importance, was only 40 m.p.h.

One of the fastest planes now in the U. S. Army Air Service is the Orenco type D pursuit fighter, equipped with a 300 hp. Hispano-Suiza engine. Near the ground the speed is 147 m.p.h. and the landing speed 50 m.p.h. The D machines contracted for by the Army were provided with twin synchronized Browning machine guns neatly mounted above the engine and entirely enclosed by the cowling. The newest and most complete accessories were installed, including leakproof gas tanks of the highest development. General specifications of the type D pursuit fighter are as follows:

Span, upper wing	30 ft. 0 in.
Span, lower wing	28 ft. 0 in.
Chord, both wings	5 ft. 0 in.
Gap between wings	4 ft. 4 in.
Stagger	1 ft. 0 in.
Length	21 ft. 6 in.
Height	8 ft. 3 in.
Weight, unloaded	1666 lb.
Useful load	766 lb.
Weight per hp.	8.1 lb.
Weight per sq. ft.	9.3 lb.

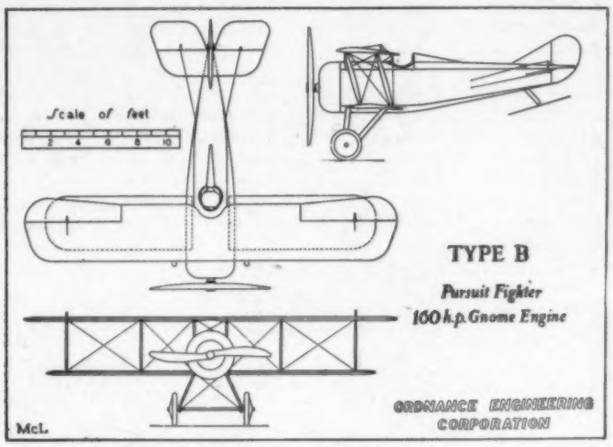
Fuel weighing 330 lb. gives an action radius equal to 275 mi. at full speed. The climb to 5,000 ft. is accomplished in 4 min. 20 sec.; to 15,000 ft., 16 min. 45 sec. In landing, the machine comes to a complete rest after a run of about 250 ft.



ORENCO PURSUIT AIRPLANE TYPE D; 300 HP. WRIGHT-HISPANO

A further development of the type D design is the D2 pursuit fighter, designed to make a speed of 165 m.p.h. with a 300 hp. Hispano-Suiza engine.

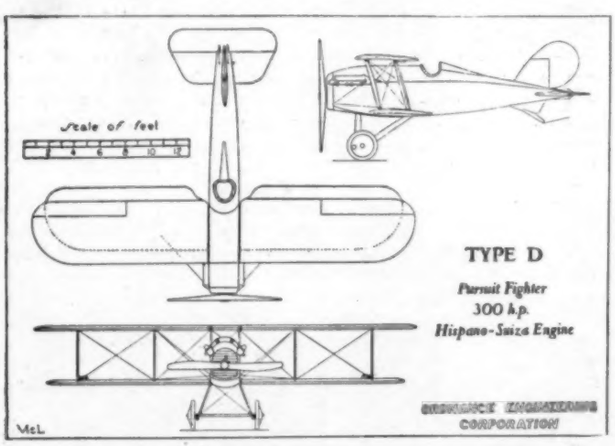
Other Orenco designs for military planes include the C2 advanced training plane, the C3 pursuit training plane, the C4 cross-country plane, the 400 hp. type E armored fighter,



OUTLINE DRAWINGS OF ORENCO TYPE B

the type E2 infantry liaison plane and the twin-motored type H2 artillery observation and fighting aeroplane.

At present the company is completing the first of its commercial planes, the type F tourist provided with a 150 hp. Hispano-Suiza engine. This plane can travel a distance of 290 mi. at the rate of about 90 m.p.h., carrying the pilot and three passengers. The side-by-side seating arrangement is comfortable and convenient. Dual controls in the rear cockpit make it possible for an inexperienced passenger to handle the machine at a safe altitude, as the pilot is able to resume control at any instant. The type F plane promises to become popular because of the simplicity of its construction, the ease with which parts can be replaced and the general efficiency and attractiveness of the design. For carrying mail or light express, the type F may be slightly modified to meet the require-



OUTLINE DRAWINGS OF ORENCO TYPE D

ments of such special services. By the substitution of floats instead of wheels, the type C plane makes a neat seaplane suitable for pleasure purposes.

For general passenger carrying and sporting uses, where lakes and rivers are available, the type I four-seater flying-boat is equivalent to the type F tourister in regard to the attractiveness of its seating ararngement and its appeal to those who seek a plane that is able to withstand continual hard usage and yet combined with the utmost in modern conveniences. A closed hood covers the passengers' and pilots' compartments, protecting them from wind and spray.

The Monaco Seaplane Meeting, 1920

The International Sporting Club of Monaco will hold the next of its annual seaplane meetings—which had been discontinued owing to the war since 1914—from Apr. 18 to May 2, 1920. The meeting will be reserved for contestants of Allied nationality, including the United States, and for seaplanes (float and boat types) constructed in the country of the contestant and fitted with engines of the same nationality. The meeting will be run under the rules and regulations of the Aero Club of France.

The main event of the meeting, called the Grand Prize of Monaco, will comprise three stages: (1) Monaco-Corsica (alighting on the sea at Ajaccio or Bastia)-Bizerta-Tunis, appr. 750 km., or 465 Sta. mi.; (2) Bizerta-Tunis-Sousse-Bizerta, appr. 500 km., or 310 Sta. mi.; (3) Bizerta-Monaco direct, appr. 750 km., or 465 Sta. m. All take-offs and alightings will be made from or upon the sea, and, as much as possible, in sheltered waters.

The Grand Prize will be competed for in the form of individual trials, each contestant being authorized to make as many take-offs as he desires during fifteen days between 6 a. m. and 6 p. m. G. M. T. Before being permitted to enter the Grand Prize race, the contestants must pass an elimination trial, comprising a climb to 2,000 m. in a maximum time of 45 min. with a disposable load (apart from fuel, oil, instruments and pilot) of 400 kg. (880 lb.), represented by ballast, and full fuel load. An allowance of 30 kg. (66 lb.) will be made for seaplanes fitted with a separate motor for the wireless apparatus. All contestants must be fitted with a 500-watt wireless sending set.

As the main idea underlying the contest is that it represents an oversea mail service, the contestants must, at each stop, hand over a sack of sand weighing 1 kg. and receive a similar sack in exchange.

Contestants arriving at a stop after 6 p. m. or before 6 a. m. will be assumed to have arrived only at the time the next control opens and to have thus missed the scheduled mail delivery. Contestants who succeed in covering more than one stage in one day will not be specially credited with such performance, each stage counting as a flight day in order to equalize the chances between contestants with regard to weather conditions.

To demonstrate the reliability of seaplanes used in mail carrying, the contestants will be placed in principle according to the number of days taken for the three stages, and, if there is a tie, according to the speed made on the third stage.

The prizes will be 100,000, 30,000, 12,000 and 8,000 francs.

The other events include a five-day altitude competition, with a first prize of 2,500 francs and daily prizes of 500 francs, and a speed contest over the 125-km. course Monaco-Cannes Monaco-Menton, for which there are prizes of 3,000, 1,500 and 500 francs. The speed contest, which will be held on Apr. 25, is reserved for seaplanes which on that date have made the best performance in climbing 3,000 m. in less than one hour.

Entries close on Feb. 29, 1920, and full details of the regulations may be obtained upon application from the International Sporting Club, 10 rue Auber, Paris.

N.A.C.A. Offices Moved

The National Advisory Committee for Aeronautics announces the removal of its offices from the fourth wing, third floor, building D, 4th Street and Missouri Avenue, N.W., to the second floor, seventh wing, of the Navy Building, 17th and B Streets, N.W., Washington, D. C.

In the future the official address of the committee, to which all communications should be addressed, will be as follows, and all parties concerned in addressing mail or other matter to the committee are requested to take notice of and use this form:

National Advisory Committee for Aeronautics,
2722 Navy Building, 17th & B Sts., N.W.,
Washington, D. C.

Superchargers and Supercharging Engines*

By Maj. George E. A. Hallett, U. S. A.

The need for aeronautic engines that will deliver the same power at 20,000 or even 30,000 ft. altitude as they develop at sea level is very real and very great, in not only military but also in commercial aviation. Much success has already been attained with supercharging devices in this country and a certain amount of success in Europe. It must be admitted that there have been some failures also. It is the intention to outline past developments in supercharging in this paper and to point out the lines of attack which seem to be meeting with most success.

Supercharging, as the term is generally used, means forcing a charge of greater volume than that which is normally drawn into the cylinders by the suction of the pistons in conventional internal-combustion engines.

When Supercharging Is Needed

At 20,000 ft. altitude the atmospheric pressure is roughly one-half that at sea level; hence about one-half the weight of charge is drawn into the engine and less than one-half the

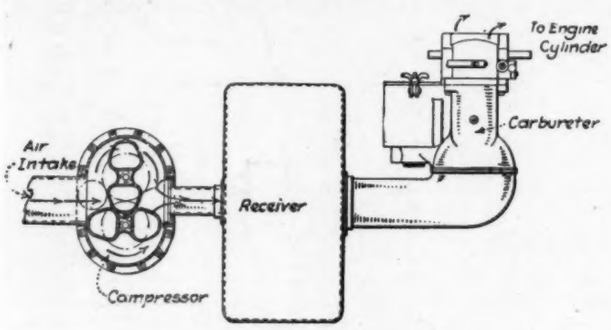


FIG. 1

power is developed. At 25,000 ft. altitude less than 25 per cent of sea-level power is delivered. If at these altitudes air is supplied to the carbureter at sea-level pressure, or approximately 14.7 lb. per sq. in. absolute, the power developed by the engine becomes approximately the same as when running at sea level. The low atmospheric pressure and density at great altitudes offer greatly reduced resistance to high airplane speeds; hence the same power that will drive a plane at a speed of 120 m.p.h. at sea level will drive it much faster at 20,000 ft., and still faster at 30,000 ft. altitude, *and with approximately the same consumption of fuel per horsepower-hour.*

There is little to be gained by supercharging at sea level to increase the power of a given size engine, because the clearance volume must be made greater than normal to prevent preignition, with consequent decrease in the expansion ratio and comparatively poor fuel economy. The fact that the clearance volume is increased removes the possibility of the engine developing full power at great altitudes unless a supercharging capacity greater than anything heretofore considered feasible is available. Supercharging, therefore, is most useful in maintaining sea-level horsepower in engines ascending to or working at great altitudes.

Superchargers

Superchargers usually take the form of a mechanical blower or pump and, of course, require a driving gear of some kind. The types of blowers or compressors used to date include the reciprocating, Root displacement and centrifugal types. The reciprocating type was tried by the Royal Aircraft Factory early in the war, on an air-cooled R. A. F. engine, with practically no success. It seems that this type of blower was found to be comparatively heavy and also unsuitable, due to the pulsating pressure of the air delivered.

The Root type blower was tried by the Royal Aircraft Factory with little or no success. The trouble reported was "rough" running of the engine on account of the pressure pulsations in the air discharged by the blower, which tended to overcharge some cylinders and undercharge others, thus causing uneven impulses. It is reported that mechanical troubles also developed with this type of blower. George W. Lewis, of the National Advisory Committee for Aeronautics, is working on an improved Root type blower, shown in Fig. 1. Here the pulsations in the air discharged are synchronized with the suction strokes of the engine. It will be interesting to note how this develops.

The centrifugal type of blower was used by Prof. Rateau, in France, early in the war. He employed the exhaust gases of the engine to drive a high-speed single-stage turbine direct-connected to the centrifugal blower, shown in Fig. 2. Some

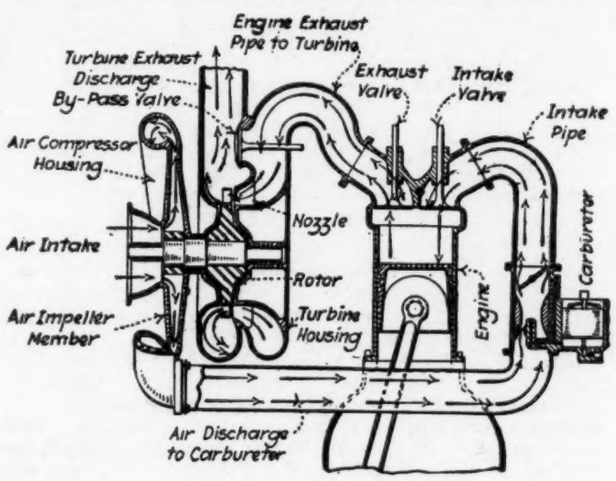


FIG. 2

success was had from the start, but he encountered many mechanical troubles. It is claimed in recent reports that some fairly good results are being obtained by the French.

The Royal Aircraft Factory experimented in 1916 and 1917 with a gear-driven centrifugal blower, but as soon as an endeavor was made to run at speeds that would stepup the pressure to the 5 or 6 lb. required, great difficulties were encountered on account of the inertia and momentum of the compressor rotor and the high-speed end of the gear-train, which resulted repeatedly in the breakage of the gears when the engine was accelerated or decelerated. To eliminate this trouble a friction clutch, designed to slip under excess torque, was tried, but only partial success was achieved, and the clutch itself gave considerable trouble. Light flexible vanes were then tried on the compressor impeller, but this expedient has not proved successful to date. Similar experiments were conducted by the A. E. F. in France but were concluded by the signing of the armistice.

The United States Air Service started work on the Rateau type of turbo-compressor soon after we entered the war. The work was done under the supervision of E. H. Sherbondy, who worked in conjunction with the Rateau-Bateau-Smoot Co. which handled the Rateau patents in this country, and designed a turbo-compressor which seemingly embodied many improvements over the Rateau type. Three of these machines were built and given ground tests on Liberty engines. Considerable trouble was encountered due to overheating of the exhaust-driven turbine, and even the use of a special heat-resisting metal in this part did not overcome the trouble. Soon after Mr. Sherbondy began work on the turbo-compressor, Dr. S. A. Moss, chief of the turbine research department of the General Electric Co., asked permission to carry on some work on the same general type. He built one turbo-compressor which was also a modification of the Rateau type but differed considerably from Mr. Sherbondy's machine. This device was

*Paper read before the Society of Automotive Engineers.

tested on a Liberty engine at the summit of Pike's Peak and developed approximately sea-level horsepower there, at an altitude of 14,000 ft. It was capable of making the engine preignite at that height. The Moss supercharger, as first built, was of rather crude construction, and much mechanical trouble was encountered with all parts except the rotating element.

After the armistice was signed all work on the development of superchargers was stopped. When the engineering division of the Air Service took over McCook Field and started to plan peace-time development, the supercharger situation was carefully considered. It was decided that it was important to continue development work along this line. It then became necessary to decide whether work should be continued on both the Sherbondy and the Moss machines, and, if not, which one should be developed. It was noted that although Dr. Moss' machine was comparatively crude, it contained some inherent advantages over the Sherbondy type, and no way was seen to overcome the faults of the Sherbondy machine. Therefore, the latter was dropped and the General Electric Co. was given a contract to rebuild the old supercharger designed by Dr. Moss. The new device is now being tested in actual flight and giving very interesting results. Figures on the results obtained with the present Moss supercharger are naturally confidential. The indications are that the turbo-compressor is very durable and probably will outlast an aviation engine.

J. W. Smith, a designer and builder of air-cooled radial engines, located in Philadelphia, is known to have designed a turbo-compressor for this type of engine. The B. F. Sturtevant Co. at Boston, Mass., has at least partially developed a belt-driven centrifugal compressor for supercharging one of its aircraft engines.

Carbureter Locations

There is still some question as to the best location for the carbureter in relation to the blower in supercharged engines. Apparently all positions have been tried:

(1) It is possible to use the centrifugal type of blower as a carbureter by placing a fuel jet within its housing and allowing the rotor to do the mixing. As the rotor usually runs over 20,000 r.p.m., it will certainly mix liquid fuel with air. This system would require a manual fuel adjustment, such as is used with the Gnome engine, for different speeds. With this arrangement there would be danger of an explosion in the blower in case the engine back-fire, because the mixture in the blower would be under pressure higher than atmospheric.

(2) The carbureter can be placed on the suction side of the blower. In this case the evaporation of the fuel will assist in cooling the charge during compression and the action of the compressor will improve the mixing of the fuel, but the danger from explosion remains to be overcome.

(3) When the carbureter is placed in the "normal" position and air is forced through it, it becomes necessary to "balance" the float-chamber with supercharger pressure. This somewhat complicates the feeding of fuel. Pressure gas-feed systems are "banned" in military planes and in any case with a pressure system that tanks would have to be made comparatively heavy to withstand the pressure which would be used at great altitudes. Where gasoline pumps are used it is necessary to regulate their discharge pressure as the plane ascends, because the fuel must reach the float-chamber at a pressure about 2½ lb. higher than that at the supercharger outlet. If the difference in fuel and float-chamber pressures is not kept in constant relation, the quality of the mixture fed to the engine will vary on account of the change in fuel level in the float-chamber. The engineering division has developed a very simple device that solves this problem effectively and is entirely automatic.

It would naturally seem at first thought that the extremely low temperatures always found at great altitudes would make possible the easy solution of cooling problems, but in reality the low density of the air reduces its heat conductivity and capacity for heat absorption to such a point that a supercharged engine developing sea-level power at 20,000 ft. requires a little *more cooling surface* than it does when developing normal power at sea level.

The Liberty engine and many others run best with a water temperature of about 170 deg. Fahr. To maintain the cooling water at this temperature in the reduced atmospheric pressure at 25,000 ft. it is necessary to use several pounds of air pressure in the radiator to prevent the water from boiling away. Very effective radiator shutters are needed when the engine is throttled to made a descent from altitudes of over 20,000 ft. to prevent the water in the radiator from freezing before warmer air is reached.

Contrary to expectations, the Moss turbo-compressor now being tested at McCook Field does not complicate the pilot's controls. On a normal engine the pilot handles the throttle and the altitude carbureter control which thins down the mixture as he ascends. With the turbo-compressor the altitude control becomes unnecessary up to the altitude at which the engine can no longer deliver sea-level power but is used, as with a normal engine, if the plane is driven higher.

With the Moss turbo-compressor, when flying at low altitudes, the exhaust pressure is allowed to "waste" through manually operated "gates" in the exhaust pipes. As the plane ascends the pilot closes these gates a little at a time and after he reaches a great altitude he can speed and retard the plane by the use of these gates. He uses the throttle only in case he wants to descend rapidly, when he closes it. In our test flights we have provided the pilot with a sealed altimeter connected only to the supercharger pressure, so that it shows to what altitude this pressure corresponds. When at great altitude the pilot closes the exhaust gates until the pressure in the carbureter causes the altimeter to show sea-level pressure. This makes it unnecessary for him to do any calculating. If he makes the gate read lower than sea level, the engine will preignite. We have already been able to obtain sea-level pressure in the carbureters at well over 20,000 ft. The exact height cannot be mentioned at present.

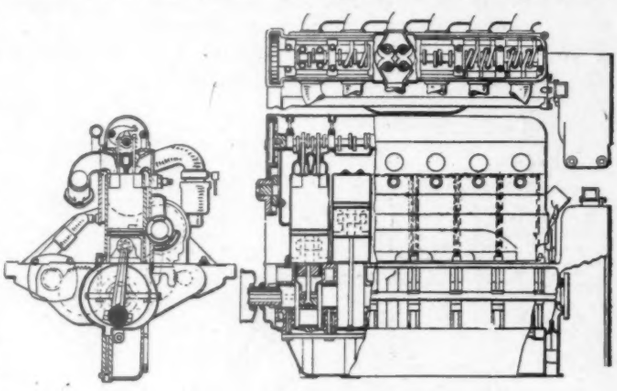


FIG. 3

With a normal engine the falling off in power as the plane ascends does not cause as much of a drop in propeller speed as might be expected, because of the reduction in density of the air in which the propeller is working. Our best engines do not lose over 75 r.p.m. at 20,000 ft. When an engine is supercharged so that the power remains constant as the plane ascends, the propeller tends to "race" at great altitudes. Therefore it is necessary either to use a variable-pitch propeller or to put on one that holds the engine speed down to low for best performance on the ground but also does not allow the engine to race too much at great altitude. In our present tests we are using an oversize propeller and getting surprisingly good results, but we also have variable-pitch propellers about ready for test and should get much better performance with them.

Supercharging Engines

As generally used, the term "supercharging engines" refers to internal-combustion engines in which compression in the crankcase or in the lower end of the cylinders is used to force an additional volume of air or mixture into the working cylinders *after completion of their normal suction stroke.* Early in the war the Army and the Navy each placed an order with the Kessler Motor Co., Detroit, Mich., for several experimental supercharging engines. This type of engine, shown in Fig. 3, supercharged each cylinder by the use of crankcase pressure, as is possible in four-cycle engines. Experiments were made using both air and mixture in the crankcase. Considerable difficulty was encountered in both the design and construction of the engine and so far as the engineering division has learned, no complete tests have been run; and in the small amount of testing that has been done no very large increase in

power or brake mean effective pressure has been shown officially. It is believed that the frictional losses will prove to be very high in this type of engine and that the supercharging will be comparatively limited. A similar engine which was tested in this country did show very high frictional loss, due partly to the work of operating the valves which controlled the crankcase air.

An interesting problem in this type of engine when using air in the crankcase is whether a rich mixture should be fed through the regular induction system and an effort made to dilute it with the supercharged air, or a normal mixture should be fed through the induction system and an attempt made to obtain perfect stratification and thus let the supercharged air merely form a cool, elastic and expanding cushion on the piston-head. It is feared that in either case it will be difficult to secure the desired results through a large range of speeds and throttle positions.

There is an English make of supercharging engine in which air is compressed under the piston and by-passed through cylinder ports at the bottom of every stroke, (see Fig. 4) supercharging, as in the Kessler engine, at the end of the suction stroke and scavenging at the end of the exhaust stroke. It is claimed by the inventor that this scavenging makes possible the use of higher compression and greatly improves the fuel economy and brake mean effective pressure. It is believed that this engine will give rather limited supercharging and it may prove difficult to control the mixing or stratification of the air and mixture at some speeds.

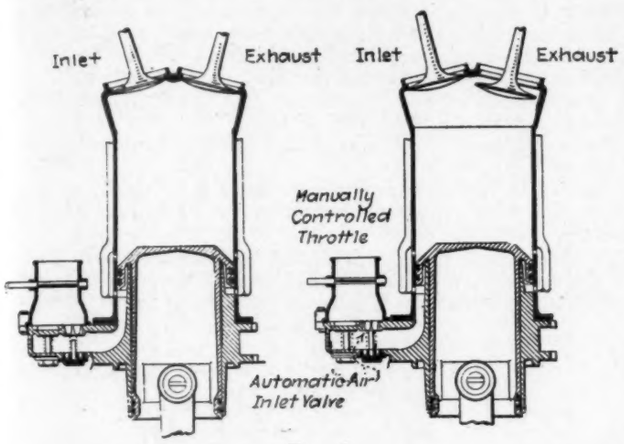


FIG. 4

In an English rotary air-cooled engine the pistons travel out to the cylinder-heads on the scavenging stroke and the beginning of the suction stroke and continue an extra distance inward at the end of the suction stroke, thus taking in a larger charge than that of a conventional engine. The piston reaches only a normal position at the end of the compression stroke and continues an extra distance inward at the end of the suction stroke, all by means of an eccentric crankpin bearing which is rotated on the crankpin by gears of suitable ratio. This type of engine must certainly give a very limited amount of supercharging.

It is believed that supercharging engines will necessarily give a rather limited amount of supercharging. It is also believed that considerable difficulty will be encountered in obtaining the desired stratification in mixing conditions in the combustion chamber through any wide range of throttle positions. Also, some mechanical friction is added in this type of engine and it must be borne in mind that friction is particularly undesirable at great altitudes because it remains nearly constant from the ground up to great altitudes while the power falls off rapidly; therefore, the mechanical efficiency of the engine becomes very low.

The Root type of blower might be interesting for supercharging purposes if the troubles caused by the pulsating nature of its discharge could be eliminated. It is hoped that Mr. Lewis' efforts along this line will meet with success.

It is already frequent practice to build aviation engines with compression so high that the throttle cannot be fully opened on the ground without injury to the engine. In this way, perhaps, the same power is obtained at 5000 ft. as can be obtained on the ground. It has been suggested that this idea be carried further and that an "oversize" engine be built with much higher compression so that the throttle cannot be opened fully until a considerable altitude, such as 10,000 or 15,000 ft., is reached. It has been stated that such an engine could be made lighter, in proportion to the cylinder sizes, than a conventional engine, on account of the fact that the throttle would never be opened near the ground, but it is believed that when this idea is investigated, it will be found that it is the inertia forces quite as much as the explosion forces that determine the necessary strength in most high-speed airplane engine parts and that therefore such an engine could not be built light enough to make it practical. In any case, it is doubtful whether this would give a really good solution for flying at 25,000 or 30,000 ft.

It is possible that centrifugal compressors can be operated satisfactorily by gears or by a belt drive. It is known that some designers are working on both of these problems.

The turbo-compressor in which an exhaust-driven turbine is used for driving the centrifugal compressor, seems to present one fairly good way of accomplishing the desired purpose. The turbo-compressor itself is very simple, as there is only one moving part, namely the rotating element consisting of the turbine wheel and compression impeller. The bearings of this rotating element do not seem to wear noticeably and the device imposes very little drag on the engine when not being used for supercharging. The turbo-compressor is also an effective exhaust muffler.

The Future of the Supercharger

It is believed that when the present type of turbo-compressor now being tested by the engineering division has been more fully developed, it can be built into an engine in a form which will add less weight and less head-resistance than the present machine, and naturally when we know exactly what additional cooling surface is required at a given height, it will not be difficult to build this cooling surface into the airplane in such a form that very little weight and head-resistance will be added.

The uses of the supercharger for military service can be divided into, first, for airplanes in which it is desired to reach extreme altitude; second, for airplanes in which it is desired to increase the rate of climb and horizontal speed and therefore maneuverability at altitudes where it is intended to fight; and, third, for airplanes which carry large loads, such as bombers, which normally are handicapped by having a very low ceiling and whose entire usefulness would, if larger engines were installed to pull them to a higher ceiling, be lost on account of the larger amount of fuel and other material that would have to be carried, thus decreasing their radii of action.

In the first case it is believed that a special supercharger can be built that will make feasible much greater altitudes than any that have been attained with the present General Electric turbo-compressor; and it is considered essential that we have airplanes capable of reaching very great heights. In the second case, it is pointed out that military machines not fitted with supercharging engines, when fighting at an altitude of 20,000 ft. or more, are so near their ceiling that their rates of climb, speed and maneuverability are comparatively poor, but the use of a supercharger seems to overcome this difficulty easily. When a pilot climbs with a normal engine to 20,000 ft. and then levels off in horizontal flight, the engine and propeller speed up perhaps 100 r.p.m. This, of course, enables the engine to develop slightly more power. In the case of a supercharged engine, especially with the turbo-compressor type of supercharger, as the engine speeds up in horizontal flight, the temperature of the exhaust and the power available from the exhaust increase, thus building up the supercharging pressure and giving considerably greater increased power than with normal engine.

The use of superchargers in commercial airplanes of the future is assured because superchargers will make possible far *more miles per hour* and *more miles per gallon* with a given engine and airplane, and speed is the main advantage of air over other kinds of transportation. It is thought by many qualified judges that by flying at a sufficient height with a supercharged engine and a suitably designed airplane, a speed of 200 m.p.h. can be maintained.

In the heavy-load-carrying type of plane which must necessarily cross mountains or perhaps fly above storms and clouds,

the necessary height can be reached with smaller, cheaper and more economical engines if they are fitted with superchargers. It is obvious that in really long cross-country flights or transcontinental flights, with mail or passengers, the logical course is to fly at 25,000 or 30,000 ft. altitude where the resistance to speed is low and great speed can therefore be attained provided the engine can deliver high power economically, which it can do if equipped with a supercharger.

As a graphic illustration of the advantage of a supercharged engine, it is pointed out that at 25,000 ft. altitude a supercharged 250-hp. engine will deliver as much power as a 1000-hp. engine without a supercharger; and of course the former will weigh many hundred pounds less, its fuel and tankage will weight very much less, the first cost will be much lower and the structure of the airplane can be made much lighter.

Torque Reaction Beds for Engine Tests

In the present state of aeronautical science, the testing of aero-engines in flight is impracticable. Ground testing must therefore reproduce, as far as possible, the main conditions existing in flight. The author favors the use of torque reaction beds, the power being absorbed by fan or propeller. These beds have the obvious advantage of cheapness and are quite accurate if suitably designed. They are easily adapted to engines of various designs and different directions of rotation. Moreover, the inclination of the engine axis during test can be usually provided for.

The author deals at great length with two factors influencing the tests; engine vibrations and exhaust reaction.

Engine vibrations are chiefly due to the reciprocating masses. A completely rigid support leads to great strains and is obviously unfair on the engine. In flight, the magnitude of engine vibrations is mainly controlled by the elasticity of the airplane structure. A rough calculation shows that only a very small part of the inertia forces of the engine are transmitted to the machine. In fact, the engine support, far from being rigid, approaches a condition of freedom. This is a matter of great importance in the design of engine test beds.

Suitable elastic supports can be easily provided for in torque

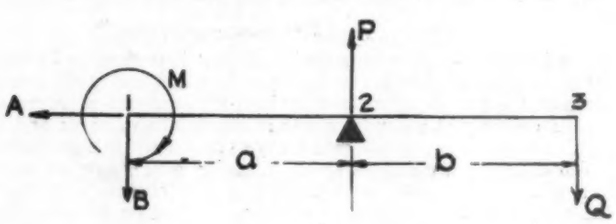


FIG. 1

reaction beds, and this is one of the main points in their favor.

The second point to which the author gives attention is that of exhaust reaction. This is, of course, included in the torque measurement of the reaction bed, and in previous tests had not been allowed for. Yet the author shows that in unfavorable cases it may amount to as much as 6 per cent of the total torque.

The different designs of reaction beds are next reviewed. They can be classified generally into:

Class 1.—Those in which the reaction axis coincides with the engine axis.

Class 2.—Those in which the reaction axis is parallel with the engine axis but does not coincide with it.

Class 1.—Coincidence of reaction axis with engine axis can be obtained in two ways:

(*a*) The bearings supporting the bed are in line with the engine axis.

(*b*) The supporting bearings are not in line with the engine axis, but the virtual axis of rotation of the reaction bed is made to coincide with the engine axis.

Method (*b*) is preferable, both on account of cost and sensitiveness. A reaction bed with bearing in line with the engine axis obstructs the air flow of the propeller. If two bearings are used, the front one must be hollow to allow the propeller drive. If only one bearing in the rear is used, a very substantial structure has to be erected in order to support a heavy engine.

A reaction bed in which coincidence of axes is obtained kinematically, however, obstructs the air flow only very little. Such beds have been constructed for the German Aero Testing Station at Charlottenburg and are described more fully in *Zeitschrift des Vereines deutscher Ingenieure*, Nov. 16, 1912. They have given satisfaction and are obviously unaffected by any forces acting through the engine axis.

Class 2.—A certain number of test beds have been used, chiefly in France, in which the rotation axis of the bed lies below the engine axis. Such an arrangement possesses high moment of inertia and great sensitiveness. It is, however, obviously affected by forces acting through the engine axis.

The absence of such forces does not seem to have been proved in the published French tests, nor has the exhaust reaction been allowed for. The tests are therefore of little scientific value.

Under the same class come also those beds which are arranged as floats and have an axis of rotation round their metacenter.

On account of its simplicity, great inertia and freedom from air obstruction, a torque reaction bed with parallel axes has much to recommend itself, provided the effect of forces through

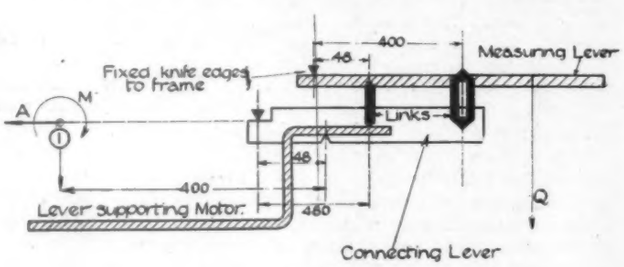


FIG. 2

the engine axis could be eliminated. A design is submitted by the author which seems to fulfill this condition in a simple form.

The sketch (Fig. 1) will make the arrangement clear.

The axis of rotation of the bed (2) is parallel with the engine axis (1) and is at the same height from the ground. The engine couple is M and through the engine axis a force is supposed to act, whose horizontal and vertical components are represented by A and B. Equilibrium is obtained by load Q at (3):

$$M = aP - (a+b)Q \quad \ldots\ldots\ldots\ldots (x)$$

$$\text{and } P = B + Q \quad \ldots\ldots\ldots\ldots\ldots\ldots (y)$$

P being the reaction of (2).

To obviate the two measurements, P and Q, bearing (2) is not fixed in space but carried by a second lever which connects (x) and (y). By suitably proportioning the different parts, P can be eliminated, as will be seen in Fig. 2.

The virtual axis of rotation of the system is at (1), Q therefore measures the torque irrespective of the forces A and B. This system has the additional advantage that by removing one of the links, the motor can be weighed in position.

The speed is estimated by a stroboscopic method, as is usual in all reaction beds.

The author states that a bed of this design is being constructed for a Berlin firm. Practical results are not yet available.

(Essay submitted to the Technical College at Breslau, by O. T. Steinitz, in 1916.)

An Investigation of Airplane Fuels

By E. W. Dean and Clarence Netzen

The chemical section of the Bureau of Mines petroleum division began its preparations for war work some little time before the United States actually entered the war, but during the first few months no attempt was made to concentrate on any specific investigation.

Shortly after the proposed airplane program of the United States was announced, W. F. Rittman and C. H. Beal of the Bureau Petroleum Division conferred with Maj. Souther of the Aviation Section of the Signal Corps, and arranged that the Bureau of Mines should undertake to study the problem of aviation motor fuel. About Aug. 1, 1917, Chester Naramore, chief petroleum technologist of the Bureau, assigned the authors to the active work of the investigation.

Fuels Suitable for Training Planes

One of the first activities of the Aviation Section of the Signal Corps was the organization and operation of schools and fields for the training of aviators and it seemed advisable, therefore, to investigate the fuel needs of the types of engines used in training planes.

The grades of gasoline obtainable in the market and used as motor fuel at this time could be divided into three classes, which for purposes of ready reference were given characteristic names by the Bureau at the time tests were begun at Langley Field.

(1) *Motor gasoline.* This grade was generally used throughout the country, and through a considerable range of physical and chemical properties, was understood to include all motor fuel having a dry point of 190 deg. Cent. (374 deg. Fahr.) or above.

(2) *Grade X Gasoline.* This type of motor fuel was produced commercially for various purposes and was understood to represent products having dry points between the limits of 160 deg. Cent. (320 deg. Fahr.) and 190 deg. Cent. (374 deg. Fahr.). This class included the gasoline generally exported, the so-called "high test" gasoline of the middle west and of certain other districts ,and the 68-70 deg. grade marketed in the Pittsburgh district.

(3) *Grade H Gasoline.* This type of gasoline was at the time of the Langley Field tests marketed in the Pittsburgh district as 73-74 deg. gasoline and was produced for special purposes in some other regions. During the gasoline shortage of the summer and early fall of 1918, it was withdrawn from the market and now seems to be definitely discontinued. For present purposes this grade was understood to include products of dry point lower than 160 deg. Cent. (320 deg. Fahr.).

Summary of Preliminary Investigation

The results of the Langley Field tests and the general information collected indicated that engines operated with volatile fuel required less careful adjustment than that required for the heavier types of gasoline but that the engineers at the various fields were getting reasonably satisfactory results without the use of a specification system for the purchase of their supply of gasoline. The problem of major importance was the study of the effect of different types of fuel upon the performance of the more highly developed types of engines used in actual military operations.

Dayton Cooperative Work

The research organization maintained by The Dayton Metal Products Co. was found to be studying the relation between the nature of fuel and the maximum compression ratio* that could be maintained in an engine without interfering with smooth operation. In the course of experiments with the air-cooled engine used with the Delco light equipment, which engine is adapted for operating on kerosene, it was found that the use of compression ratios above a certain limiting value caused what was described as "the kerosene knock" or "pinking" (if kerosene was used as motor fuel). An engine showing this undesirable phenomenon could be operated smoothly if the fuel were properly selected. Benzol-kerosene or even gasoline-kerosene mixtures were notably superior to kerosene, and certain chemicals, particularly alkyl iodides, had specific "anti-knocking" properties. This phenomenon had been studied intensively and important information obtained as to its nature and the methods of preventing it. It was believed that this "knocking" or "pinking" was the chief factor that limited the compression ratios of airplane engines to the maximum figures maintained in standard practice, these being of the order of 5.4 to 1.

The work of the Dayton research laboratory had shown the necessary characteristics of fuels capable of standing higher compressions and meeting all the other necessary requirements for successful performance and it seemed that this investigation could be applied with great advantage to the aviation fuel problem. It was arranged that the Bureau of Mines and the Research Division of the Dayton Metal Products Company should cooperate in ascertaining what fuels capable of standing high compressions were most desirable and most practical and whether or not the indications resulting from tests with the small Delco engine were supported by experience with larger motors. It was realized that this line of investigation offered a possibility of materially increasing the power of airplane engines at the expense of very slight increases in weight and with no important mechanical alteration except the substitution of high-compression pistons.

Preparation and Obtaining of Fuels

Preliminary experiments of the Dayton laboratory had shown that the chemical properties of the fuels were more important than physical properties. Samples of gasoline were therefore obtained that were derived from different varieties of crude petroleum. Synthetic or cracked gasolines were obtained from companies operating several different cracking processes. Benzol was obtained and was used as such and in the form of various mixtures. Alcohol and alcohol mixtures were obtained and prepared. In addition an extensive research was devoted to the production of cyclohexane (otherwise named hexahydrobenzene or hexamethylene). The history of this investigation is interesting and as this product later proved of considerable importance, an account of the work is given in brief.

In the course of the conferences previously mentioned the authors were frequently advised that the Germans were using cyclohexane as airplane motor fuel. These statements were somewhat disconcerting, as it was realized that the obtaining of cyclohexane in sufficient quantity for actual tests involved considerable difficulty. During the early stages of the Dayton cooperation the senior author had an opportunity to review the original and sole evidence upon which was based the rumor that the German aviation service had been using cyclohexane. This evidence was in the form of a report from a French laboratory of the analysis of some gasoline taken from a captured German airplane. It was found that the figures contained in this report had been misinterpreted and that they indicated the absence rather than the presence of cyclohexane in the German gasoline. In this connection it may be mentioned that there seems to be no evidence that German airplanes operated with anything but a good grade petroleum gasoline at any time during the entire war.

Upon his return to Dayton with the news that the cyclohexane problem was solved, the senior author was informed that a review of the properties of this hydrocarbon indicated that it might be exactly the fuel that was required for high compression engines. It was believed that in spite of their reputed efficiency the German engineers had missed a bet. Experimental work on the hydrogenation of benzol was al-

* The term compression ratio means the ratio between the volumes in an engine cylinder above the piston when the latter is respectively at lower and upper dead center. A figure in pounds per square inch is sometimes used instead of the ratio figure, this representing the pressure developed by compression when the engine is turned at a certain speed under definite conditions.

Both the maximum horsepower and the thermal efficiency of an engine can be increased by increasing the compression ratio. The maximum desirable value for the latter is controlled by a number of factors, mechanical as well as chemical.

ready in progress in the Dayton laboratory and developed shortly into an activity that proved highly interesting and important. The preparation of this fuel involved considerable difficulty and the earlier results were not very promising as regards ease of production, although the expected advantages of cyclohexane were demonstrated the first time it was tested in an engine. A detailed description of the investigation devoted to the hydrogenation of benzol is to appear in a future technical paper of the Bureau and for the present it may simply be stated that the initial production of a pint per week of 24-hr. days was subsequently increased to a maximum of 28 gal. per 24 hr. day. No evidence was obtained that even this quantity was the maximum that could be handled in a single hydrogenating unit and there was every reason to believe that successful large scale operation could be attained in a relatively short time.

The motor fuel actually tested after the first few engine runs was not pure cyclohexane but a mixture called "hecter," composed of from 70 to 80 per cent of cyclohexane and 20 to 30 per cent of benzine (benzol). Both cyclohexane and benzine have freezing points in the neighborhood of 5 deg. Cent. (41 deg. Fahr.) and if used pure are not suitable for airplanes operating at temperatures ranging down to considerably below zero Fahrenheit. The mixture of cyclohexane and benzine in the proportions used for hecter has, however, what is known as an eutectic point and freezes in the general neighborhood of 40 deg. Fahr. below zero.

Engine Tests of Various Fuels

Through the courtesy of the engineers at McCook field the Bureau obtained the loan of a testing engine made by equipping one cylinder of a standard Liberty engine with a special crank case, shaft and fly-wheel. A set of pistons was obtained which gave compression ratios ranging between 5.3 to 1 and 8.2 to 1. (Pressures measured with an Edelman gage with the engine turned at 400 r.p.m. varied from 113 to 185 lb. per sq. in.). The use of dynamometer and machine-shop facilities were provided by Mr. J. H. Hunt, in charge of the research department of The Dayton Engineering Laboratories Company.

A considerable number of fuels were tested with this equipment and results obtained showing that gasoline composed of paraffin hydrocarbons had a marked tendency to knock at the 5.3 to 1 compression ratio, whereas hecter, benzol, alcohol, and a special alcohol-benzol-gasoline mixture (Taylor Fuel No. 4) showed only a slight tendency to knock under an 8.2 to 1 compression ratio.* Cracked gasolines and California gasolines were intermediate in resistance to knocking and were notably better in this respect than the paraffin base products which have in the past been highly esteemed as motor fuel. This superiority is attributed to the presence of unsaturated and cyclic hydrocarbons in the cracked distillates and to cyclic hydrocarbons in the California gasoline. Many of the fuels that resist knocking have undesirable properties that more than overbalance this advantage and at a last analysis the most promising product was found to be hecter, with California gasoline or gasoline-benzol mixtures a second choice. Hecter was considerably superior in resistance to knocking and was used in subsequent tests to determine the advantages of equipping airplane engines with high compression pistons. It was believed that additional tests with hecter would settle the proposition of using special fuels and super-compression ratios and that even if hecter was found to have specific unfavorable properties not heretofore detected, it would still be possible to select or prepare fuels that were superior to gasoline derived from paraffin or intermediate base crude oil.

Supplementary Tests

A full set of twelve special pistons was obtained permitting the adjustment of a standard Liberty engine to a compression ratio of 7.2 to 1. This engine was put in a DeHaviland No. 4 plane and two trial flights made at McCook field. Results were unfavorable as trouble was experienced with actual preignition of the fuel which is a phenomenon distinct from knocking or pinking.

The same pistons were transferred to the experimental field of the Dayton Wright Airplane Co. and another Liberty engine tried in a DeHaviland plane. The hecter was changed slightly in composition so that it contained 70 per cent of cyclohexane and 30 per cent of benzine instead of being the original 80-20 formula. (Benzine and benzine mixtures were shown by Mr. E. F. Hewitt to have notably higher ignition temperatures than other hydrocarbons and it was believed that the trouble experienced at McCook field could be obviated in this way). The results of this series of flights were favorable, the engine operating smoothly and yielding the additional power that was to have been expected on account of its high compression ratio.

The high compression pistons were then transferred to Wilbur Wright field and a test flight made. Official permission to publish results of this test has not yet been received but it may be said that they were even more favorable than the results of flights made at the Dayton Wright field. The engine operated satisfactorily and gave the increased power output that its high compression ratio warranted.

As a final test of the feasibility of using high compression ratios in engines employing hecter as motor fuel the pistons were installed in an engine in the altitude chamber of the Bureau of Standards. Here again the theoretical superiority in power output was substantiated and no difficulties were discovered incident to the use of the special fuel.

The tests just described were all that have been made up to date with actual aviation engines and it is of course possible that extensive use of high compression engines by ordinary operators would show up disadvantages that have not as yet been discovered. It appears, however, that with the single exception of the readily eliminated trouble with preignition at McCook field the tests with multi-cylinder engines are in complete agreement with those made with the single-cylinder engine.

* The experimentors were unable to operate the engine successfully with a piston giving an 8.2 to 1 ratio on account of mechanical difficulties. These may or may not have been possible to obviate but the 7.7 to 1 ratio that did permit successful operation was considered high enough to serve as an upper limit for the series of tests.

TWIN DH MAIL PLANE, FITTED WITH TWO LIBERTY SIX ENGINES. THIS MACHINE HAS A MAIL-CARRYING CAPACITY OF 650 LB.

Velocity and Stresses in a Glide*

By Comdr. J. C. Hunsaker (C.C.), U. S. N.

"From an investigation of the wreckage on the spot and from testimony of eyewitnesses, it was established that Victor Carlstrom with a passenger in a Curtiss model J. N. 4B airplane climbed to a height between 2,500 and 3,500 ft. and then started to glide at about 45 deg., with full power. After gliding at this angle for about 800 ft., the airplane was pulled out of the glide very quickly, the pilot undoubtedly intending to loop. He had looped several times before with the same machine. In pulling out of the glide the right wing collapsed and the machine fell to the earth, killing both pilot and passenger. Most of the airplane structure was badly broken in the fall and it was impossible to tell, from the wreckage, which member failed first. All of the flying and landing wires in the rear of the wing truss were broken, but all of the front wires were intact. As none of the right wing struts was to be found in the wreckage, they were probably broken in the air and drifted away from the rest of the machine. None of the metal fittings was broken, with the exception of a few that were broken in striking the ground, and none of the wires was broken in the splice. The wood in the wing structure seemed to be of a good quality, and it seems certain that the accident did not result from the use of inferior material. All spars bore Army or Admiralty inspection stamp.

"Carlstrom had looped with this machine a number of times, and on the morning of the accident a number of bad landings were made with the same machine. It is possible that the machine may have been severely strained previous to the accident. It is known that Carlstrom pulled out of the glide very quickly, and in all probability the machine was overstressed by so doing. Since the front inner lift cables were not broken and as a failure of the front outer strut might not be serious, the accident probably resulted from the front spar giving way."—*Report by Inspector of Aeronautic Material J. M. Rogers, on airplane accident of May 9, 1917, at Newport News, Va.*

The slip of an airplane propeller is not more than 30 per cent; consequently on a steep dive with power, if the engine is not allowed to race, the slip and hence the thrust vanish for a speed about 50 per cent in excess of normal speed. Such speeds are easily attained, as will be shown below.

If the engine is throttled down in a glide, the slip quickly becomes negative and the propeller acts as a brake, preventing the attainment of excessive speeds. The exact amount of such brake action is not known but must be considerable. Experiments at the University of Paris with a Gnome-engined Blériot monoplane showed that, on a glide, the propeller cranked the engine as a windmill and absorbed power equivalent to an additional resistance of about 20 per cent. The Gnome is a low-compression engine which will work in this manner when the ignition is cut.

It is probable that an ordinary engine throttled down to minimum revolutions is a more effective brake on a glide than when stopped dead.

To consider a general case, assume an airplane descending at an angle A to the horizon with engine running full power. Neglect the thrust of the propeller, which only acts in the beginning to hasten the realization of the final or terminal velocity, and also neglect the relative decrease in the airplane's resistance due to absence of the propeller blast.

Modern airplanes, especially those used for school purposes, are given ample wing surface to permit reasonably slow landing, and when high speed is desired an engine giving 100 or 200 per cent power in excess of the minimum for flight is used. Consequently, at its highest speed the airplane has unnecessarily large wings and must fly at a small angle of incidence. This angle of incidence at high speed may be within 3 to 5 deg. from the angle of no lift. The latter is usually an angle of about —3 deg. between apparent wind direction and chord of wings. From the angle of no lift up to an incidence 5 deg. greater, wind tunnel tests show that for constant velocity the resistance of all airplanes remains very nearly constant.

Knowing the maximum horizontal speed, V_o, made by a given airplane, and making reasonable assumptions as to brake horsepower, P_o, and propeller efficiency, e, a very fair estimate of its resistance, R_o, may be made. Thus:

$$R_o = \frac{550\, eP}{V_o} \tag{1}$$

Since the resistance is known to vary approximately as the square of the velocity, and it is explained above that no important decrease in resistance is to be expected from the smaller angles of incidence, we have at some greater speed, V:

$$R = R_o\left(\frac{V}{V_o}\right)^2 = KV^2, \tag{2}$$

where $K = \frac{R_o}{V_o^2}$.

If the weight of the airplane is W and the angle of descent to the horizon A, we have the component of gravity giving propulsion opposed by the inertia and air resistance of the airplane. The equation of motion is:

$$W \sin A = \frac{W}{g}\frac{d^2s}{dt^2} + K\left(\frac{ds}{dt}\right)^2. \tag{3}$$

Substituting $V = \frac{ds}{dt}$ and separating the variables, the order of the equation is reduced by one and the variables may be separated by inspection:

$$\int \frac{dV}{W \sin A - KV^2} = \int \frac{g}{W}\, dt, \tag{4}$$

giving on integration:

$$\frac{1}{2K\sqrt{\frac{W}{K}\sin A}} \log_e \frac{\sqrt{\frac{W}{K}\sin A} + V}{\sqrt{\frac{W}{K}\sin A} - V} = \frac{g}{W}t + C. \tag{5}$$

The constant of integration may be found, knowing that initially when $t = O$, $V = V_o$, or the normal high speed.

$$C = \frac{1}{2K\sqrt{\frac{W}{K}\sin A}} \log_e \frac{\sqrt{\frac{W}{K}\sin A} + V_o}{\sqrt{\frac{W}{K}\sin A} - V_o}. \tag{6}$$

The ultimate or terminal velocity T, reached, is found when the acceleration is zero. Putting $\frac{dV}{dt} = O$ in (3), we have:

$$T = \sqrt{\frac{W}{K}\sin A}, \tag{7}$$

and substituting (6), and (7), in (5), and throwing into exponential form:

$$e^{\left(\frac{2gKT}{W}\right)t} = \frac{(T+V)\,(T-V_o)}{(T-V)\,(T+V_o)}. \tag{8}$$

It appears from (3) that speed is picked up quickly since the acceleration is greatest when the velocity is least, but from (8) we see that theoretically an infinite time must elapse before the terminal velocity is reached. In other words, the velocity approaches the terminal velocity as a limit.

The integration of the motion in space instead of time coordinates affords additional light and is readily effected by—

$$\frac{d^2s}{dt^2} = \frac{dV}{ds}\cdot\frac{ds}{dt} = V\frac{dV}{ds}. \tag{9}$$

V	V	V^2	T^2-V^2	$\frac{T^2-V_o^2}{T^2-V^2}$	$\log_e \frac{T^2-V_o^2}{T^2-V^2}$	S	Excess Speed.
Miles.	*Ft. sec.*					*Ft.*	*Per Cent.*
75	110.0	12100	33700	1.000	0.00000	0000	0
100	146.5	21450	24350	1.385	0.32570	326	33
130	190.0	36100	9700	3.470	1.24420	1240	72.5
140	205.0	42000	3800	8.880	2.18380	2184	86.5
146	214.0	45800	00000	∞	∞	∞	95

* Aircraft Technical Note, Bureau of Construction and Repair, Navy Department.

Substituting in (3):

$$\frac{W \sin A}{K} = \frac{W}{gK} V \frac{dV}{ds} \times V^2 = T^2, \tag{10}$$

and integrating:

$$\left.\begin{aligned} \int \frac{V dV}{T^2 - V^2} &= \frac{gK}{W} \int ds, \\ s &= \frac{W}{2gK} \log_e \frac{T^2 - V_o^2}{T^2 - V^2}, \end{aligned}\right\} \tag{11}$$

or

$$e^{\left(\frac{2gK}{W}\right)s} = \frac{T^2 - V_o^2}{T^2 - V^2}.$$

Here as in (8), V approaches T as a limit, rapidly at first, and then slowly.

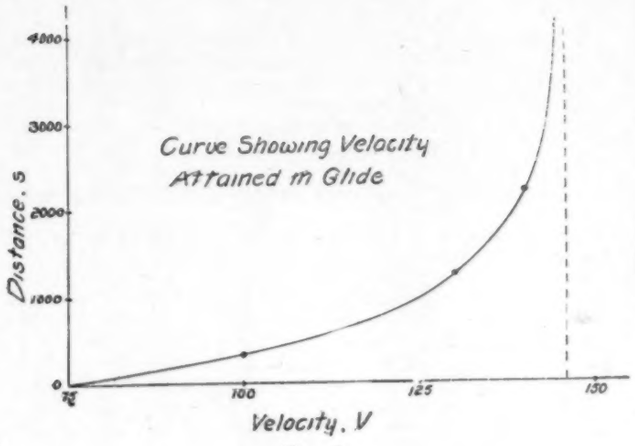


FIG. 1

To fix ideas, consider the typical school airplane of the following characteristics:

$A = 45$ deg. glide.
$W = 2000$ lb.
$P = 100$ hp.
$e = 75$ per cent.
$V_o = 110$ ft. per sec.

Hence:

$R_o = 375$ lb.
$\frac{W}{R_o} = 5.33.$
$K = 0.031.$
$T = 214$ ft. per sec. or 146 m.p.h.
$\frac{W}{2gK} = 1000.$

It appears, then, that a dive of 1000 ft. at 45 deg. to the horizon will cause this machine to acquire a velocity nearly 70 per cent in excess of its normal maximum speed. The time to acquire this excessive velocity will be less than 10 sec., if power is left on, and it should be noted at this place that in the calculations the acceleration due to propeller thrust in the initial stages has been neglected.

Velocities much in excess of normal may be reached voluntarily by a pilot in trick flying, or involuntarily in a nose dive following a stall, or other temporary loss of control, and it is of interest to examine into the structural strength of our machines under such abnormal conditions.

The typical airplane chosen above flies normally at an angle of incidence of 2 deg. The angle of no lift is about — 4 deg. to the wing chord, and from this point the lift curve plotted on angle of incidence is practically a straight line.

In order to maintain a straight trajectory on a glide, the component of the weight normal to the direction of motion must equal the normal aerodynamic reaction of the wings. This reaction in horizontal flight is vertically upward and is called lift. For convenience, let us continue to call this reaction, lift. The approximate law of its variation is, therefore,

$$L = C\, i\, V^2 = W \cos A, \tag{12}$$

where C is a constant for a particular machine and arrangement of surfaces, and i the angle from no lift.

In our particular case $i_o = 6$ deg. and $V_o = 110$ ft./sec. Then for $V = 190$ ft./sec.,

$$\frac{W}{W \cos A} = \frac{C i_o V_o^2}{C i V^2}, \text{ or } i = i^\circ \left(\frac{V_o}{V}\right)^2 \cos A = 1.4 \text{ deg.} \tag{13}$$

The airplane on the 45 deg. glide is flying at an angle of 1.4 deg. from the angle of no lift, or with the wing chord inclined — 2.6 deg. to the relative wind. The lift load on the wings is not excessive, but the resistance or drift load is nearly 2.5 times the amount in horizontal flight. The rear wing spars are, therefore, put in compression by the latter load, and at this angle the rear spars are carrying practically the entire lift load. However, modern airplanes are usually able to support this load with safety.

The really dangerous condition commences immediately when the pilot turns up his elevator to pull out of the dive. It is usual to provide a control system giving such a mechanical advantage that a strong man is able to throw the elevators hard up even when making excessive speed. Consider the pull on the control wheel to be 75 lb., which, in this particular case, would give a resulting moment of 1500 in.-lb. about the hinge of the elevator. The pressure on the elevators would then be about 100 lb., which would give a moment of approximately 1700 lb.-ft. about the center of gravity of the machine. Assuming the radius of gyration of the above plane as 5 ft., giving us a moment of inertia of mass of 1550 lb., the angular acceleration would then be:

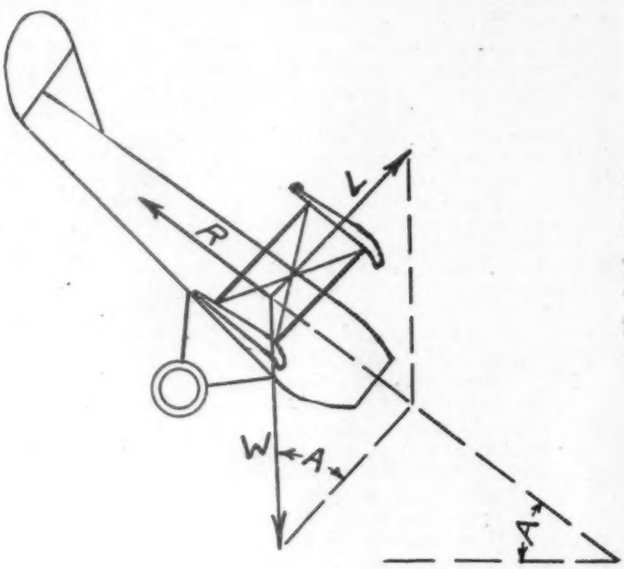


FIG. 2

$$\frac{dw}{dt} = \frac{M}{I} = \frac{1700}{1550} = 1.1 \text{ radians sec.}^2 \tag{14}$$

It is evident from this large angular acceleration that the machine can be pulled out of a dive very quickly by exerting a pull of 75 lb. on the control bridge. At a speed of 130 m.p.h. and an angle of incidence of 14 deg. the factors of safety of several of the structural members of the machine become unity. It does not seem reasonable that the change of angle should require more than 0.5 sec. and the machine ought to lose but a small amount of its velocity in so short a time. Therefore it is to be expected that some structural member of the machine will fail.

The above calculation is based upon several assumptions, but such assumptions are considered plausible. The conclusion is evident that any airplane of usual construction can be wrecked in the air by severe abuse.

The Variable Angle of Incidence Airplane

The problem of the variable angle of incidence machine may be considered from four points of view.

(I) Aerodynamical efficiency.
(II) Longitudinal stability and controllability.
(III) Structural reliability.
(IV) Landing possibilities.

Aerodynamical Efficiency.—The resistance of a plane is divided into two parts, wing drag and parasite resistance. This parasite resistance forms a large percentage of the total resistance of the airplane, and the variable angle of incidence machine is an attempt to reduce it. The parasite resistance of a plane is approximately least when the fuselage is in the line of the wind. When the airplane flies at a higher angle, and the fuselage is at a greater angle to the wind, the parasite resistance increases accordingly. In the variable angle of incidence machine, the fuselage, chassis, etc., are maintained in the line of the wind with a theoretical gain in efficiency. In practice it is very doubtful whether this theoretical gain in efficiency is realized.

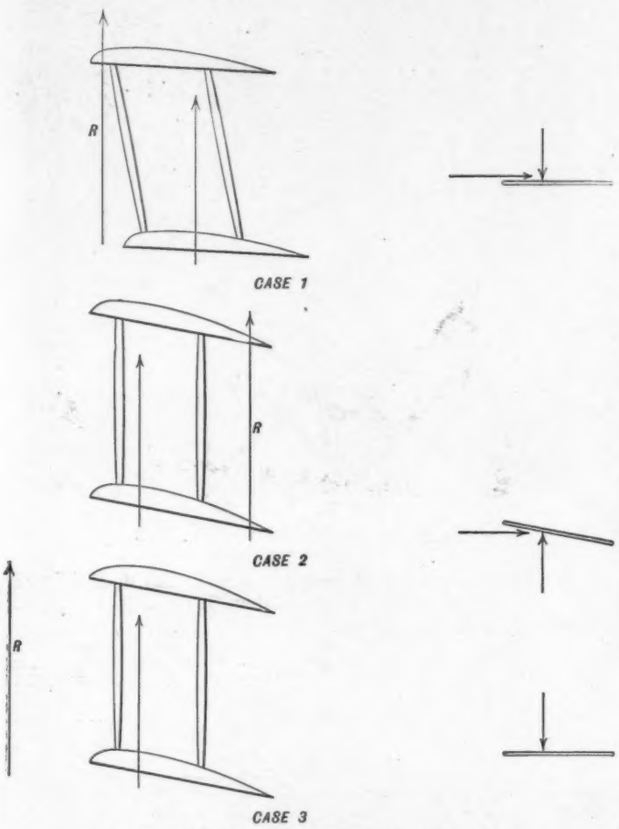


FIG. 1. CASES OF LONGITUDINAL STABILITY

To discuss the question, we can base computations on investigation of parasite resistance conducted at the Massachusetts Institute of Technology (Research Department Memorandum No. 31) and on report No. 16 (1917) of the National Advisory Committee on Aeronuatics.

In these two reports a careful analysis of the resistance of the Curtiss JN-2 has been made. This machine has an angle of incidence of 3 deg. to the wings. If the machine is flown at 10 deg. the body of the Curtiss JN-2 is at 7 deg. to the wing. If we imagine the Curtiss fitted with variable angle of incidence there would be a saving equal to the difference between parasite resistance at 7 deg. and parasite resistance at 0 deg. But to balance the slight saving shown, we must make allowance for the resistance of the superstructure which the variable angle of incidence machine necessitates.

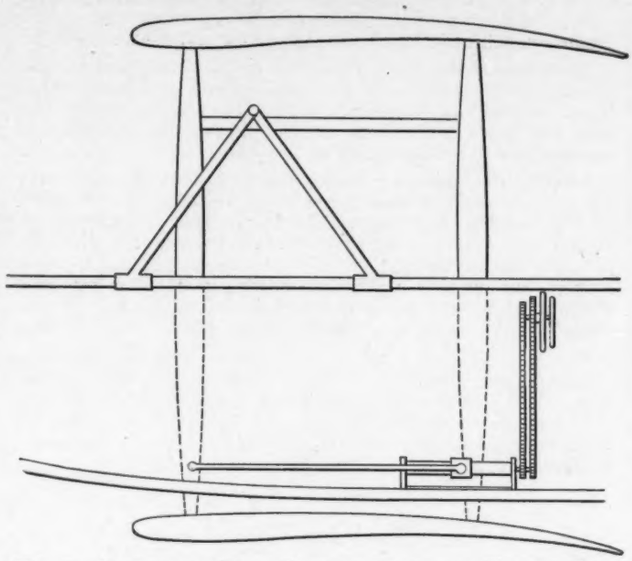


FIG. 2. DIAGRAM OF PAUL SCHMITT INCIDENCE CHANGE GEAR

The superstructure of the Lanzius was taken as a basis for these computations. Since this superstructure might be considerably improved, and since the JN-2, if not a smaller machine, has less stresses to withstand, the parasite resistance of the Lanzius has been reduced by 50 per cent in applying to the Curtiss. The final resistance and horsepower curves show that there is finally a loss and not a gain in the variable angle of incidence machine, and this purely on grounds of resistance. The increased weight due to complication of the mechanism would work still further against this type of airplane.

Longitudinal Stability and Controllability.—To study this thoroughly, a great deal of wind tunnel experimentation would be necessary, but the simple diagrams in Fig. 1 indicate that the variable angle of incidence machine would have a tendency to stall at large angle of incidence and be very disconcerting to the pilot. At small angles, the tail would act as on an ordinary machine, i.e., a non-lifting tail tending to prevent nose heaviness; this is indicated in Case 1.

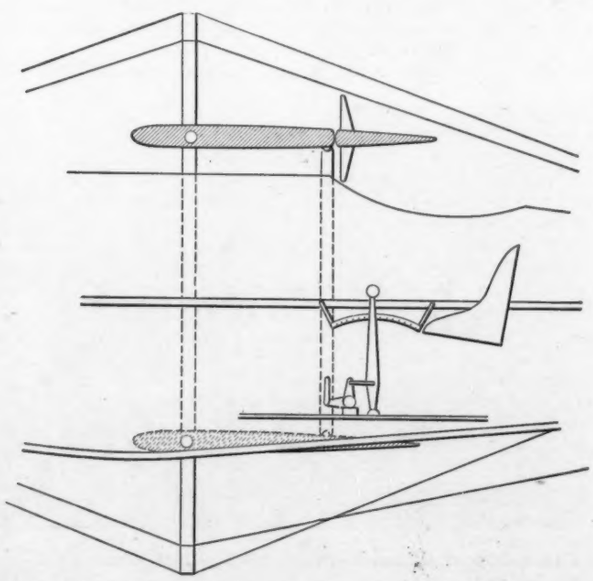


FIG. 3. DIAGRAM OF LANZIUS INCIDENCE CHANGE GEAR

Case 2 is that of an ordinary machine at a big angle of incidence where the tail is now a lifting tail, preventing stalling. In Case 3 we have the variable angle of incidence machine at a big angle. Its tail is non-lifting and stalling action occurs. Such a machine would therefore present very considerable difficulties in longitudinal stability and control.

Structural Reliability.—In Figs. 2 and 3 are shown diagrammatically the mechanisms of the Paul Schmitt and the Lanzius. These are self explanatory. Without any close study, it is seen that these mechanisms are complicated, add weight and scarcely add to the reliability of the plane.

Landing Possibilities.—An advantage sometimes claimed for the variable angle of incidence machine is that it can be landed at low speed with horizontal fuselage. This is rather detrimental than otherwise in a land machine, where it is desirable to touch the wheels and tail skid to the ground at the same instant, but may be a great advantage in a water machine, where whatever the speed of flight, the machine can be "laid down" on the water with the float in its normal running position.

Conclusion.—Since there is no aerodynamic gain and possibly slight loss, complication, added weight and no compensating advantages, the future of the variable angle machine seems very doubtful.—*Excerpt from a report of the Aeronautic Research Department, McCook Field.*

Handley-Page Type W.8

The Handley-Page W.8 transport airplane is the first post-war product of this firm. It is designed so as to provide a single large saloon 22 ft. long, 4 ft. 6 in. wide and 6 ft. high, which affords accomodation to from fifteen to twenty passengers. The space provided is entirely unobstructed by wires or cross struts, and when used for carrying cargo entirely, 470 cu. ft. of space is available. Pilot and engineer are in a well sheltered cockpit immediately forward of the saloon.

Port hole windows, which can be opened or shut, are provided along each side of the passenger cabin, one for each occupant. In the floor, lenses are fitted in order to provide a direct view downwards.

The interior of the saloon is lavishly equipped with carpets, curtains, electric light, lamps, clocks, mirrors, wireless apparatus, telephone, lavatory. Flower vases and velvet cushioned arm chairs with receptacles for maps, books and papers give the machine the appearance of a comfortable Pullman car.

When carrying large consignments of cargo, light racks, shelves and cupboards can be fitted on either side of the cabin, leaving a central gangway. Large doors are fitted in the side of the machine and there is a trapdoor in the floor to facilitate the entry and removal of freight. A door also communicates between the passenger saloon and the pilot's cockpit.

The engines are provided with effective silencers to enable conversation to be carried on amongst the passengers.

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SPECIFICATION AND PERFORMANCE

Type of machine	Twin engine biplane
Engines	Two Napier Lion
Maximum available hp	450 hp. each engine
Cruising hp.	350 hp. each engine
Performance with normal maximum hp.—	
Speed (maximum)	112 m.p.h.
Normal cruising speed	90 m.p.h.
Landing speed	45 m.p.h.
Duration of flight	6½ hr.

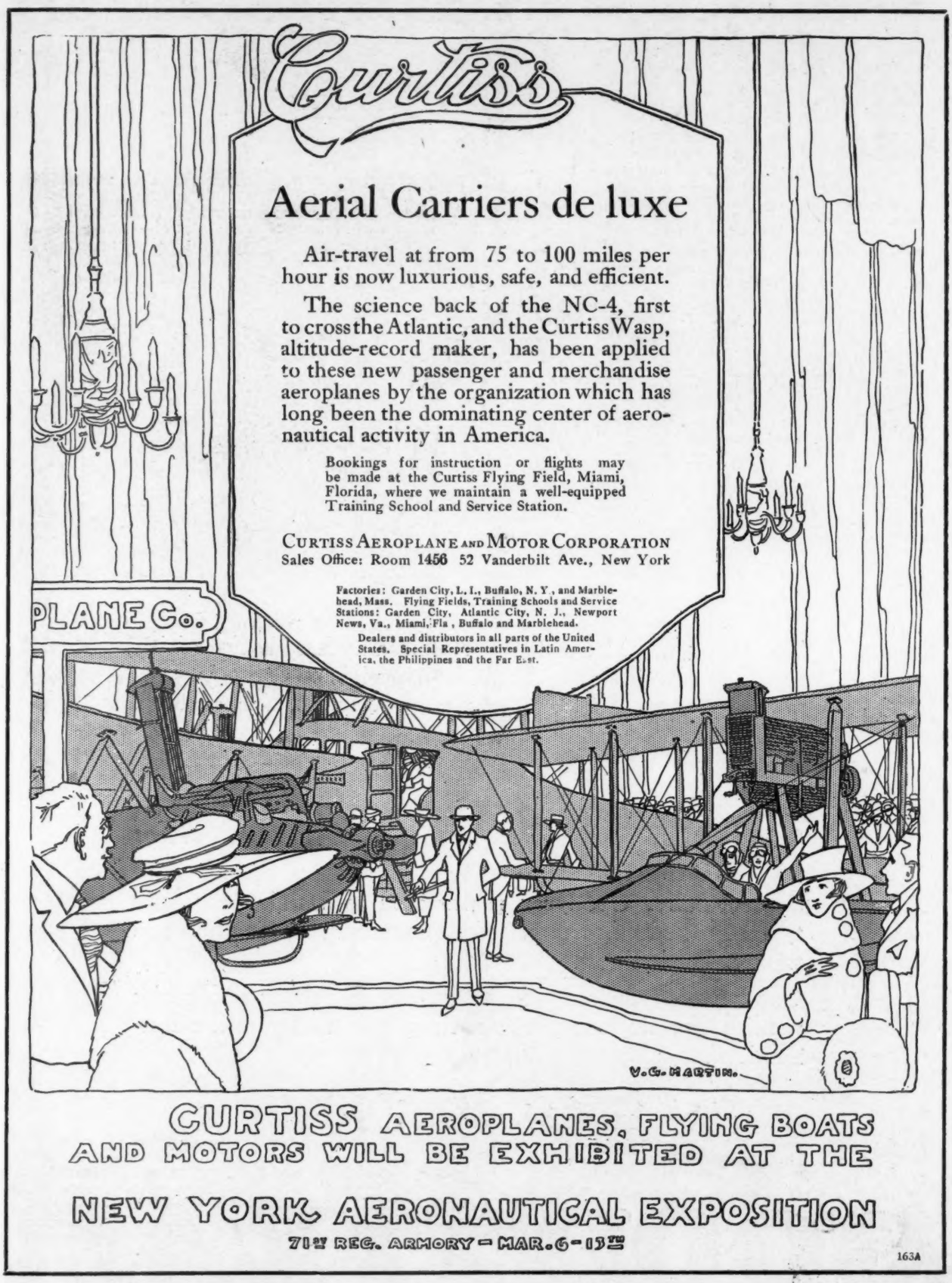
CABIN OF THE HANDLEY-PAGE W-8
Photo International

From fifteen to twenty passengers or 2 tons of freight can be carried. For shorter distances than 500 mi. the weight can be correspondingly increased.

DIMENSIONS

Main plane span	75 ft.
Overall length	60 ft.
Overall height	17 ft.
Maximum width with wings folded	29 ft.
Total gasoline capacity	250 B. I. gal.
Total oil capacity	37.5 B. I. gal.

THREE-QUARTER REAR VIEW OF THE HANDLEY-PAGE TYPE W-8. THIS MACHINE RECENTLY FLEW FROM LONDON TO PARIS IN 2 HR. 10 MIN. (240 MI.)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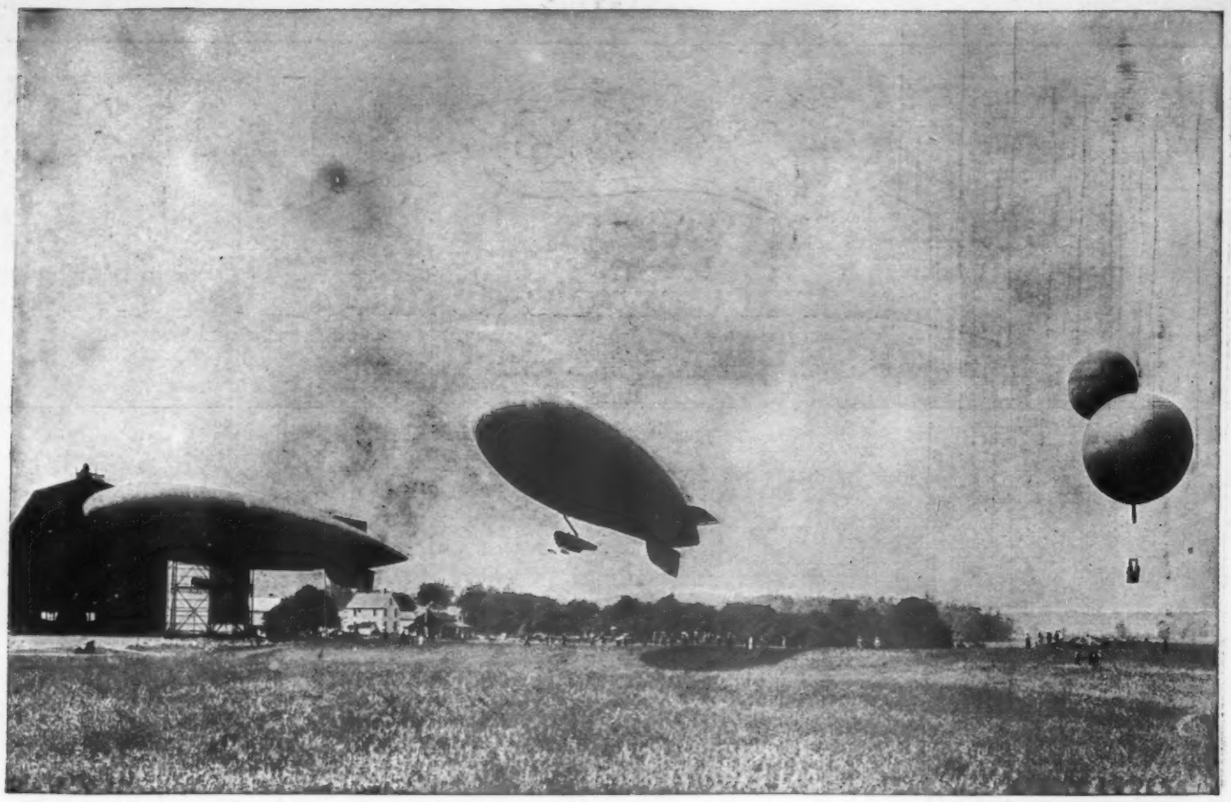

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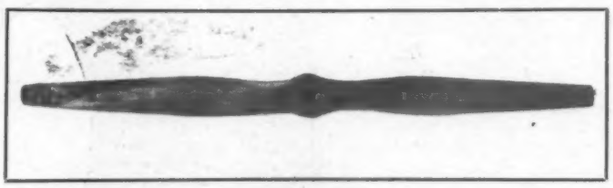

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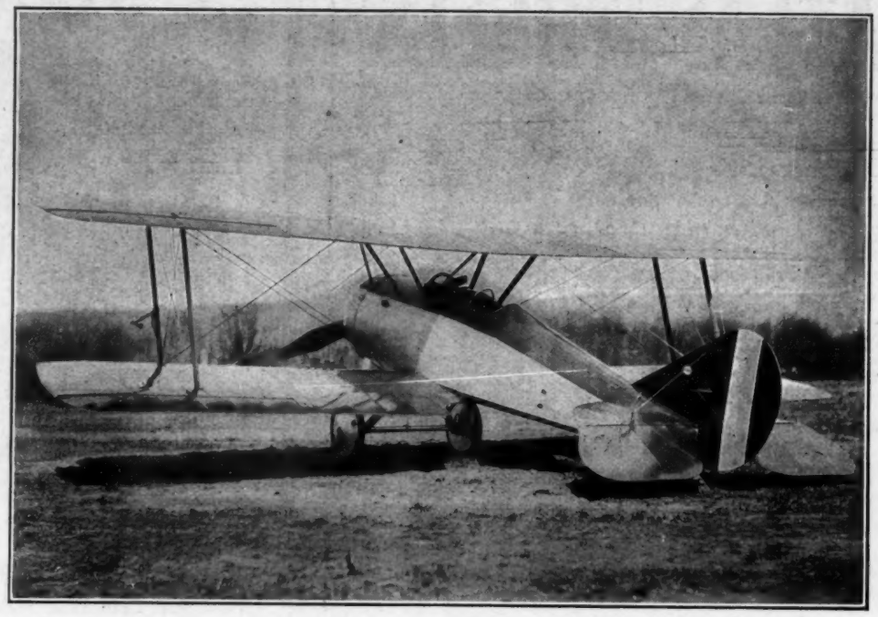

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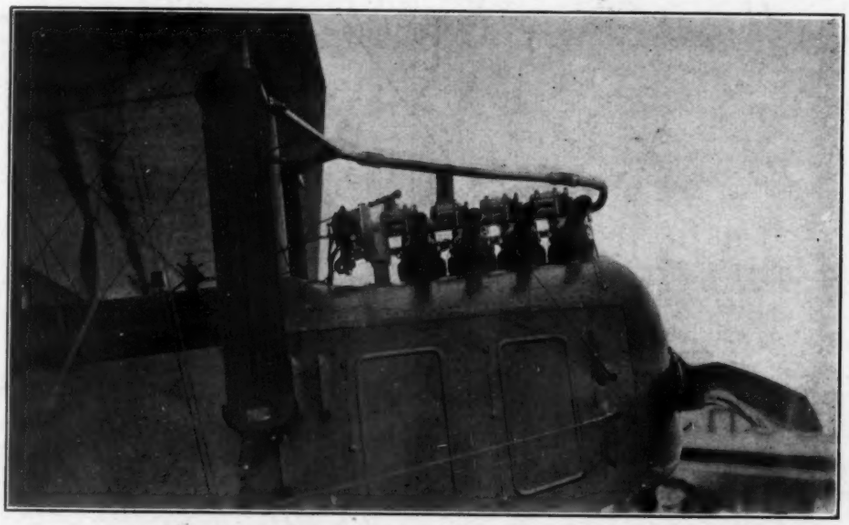

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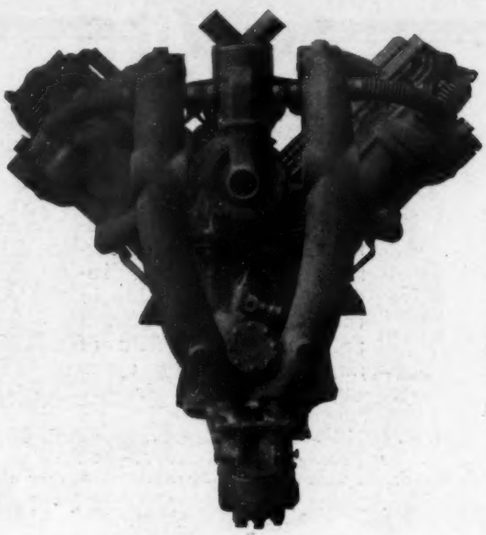

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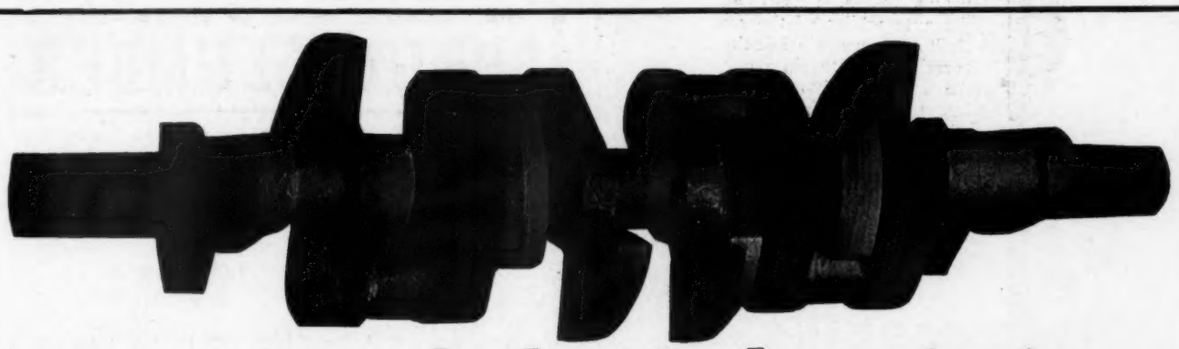

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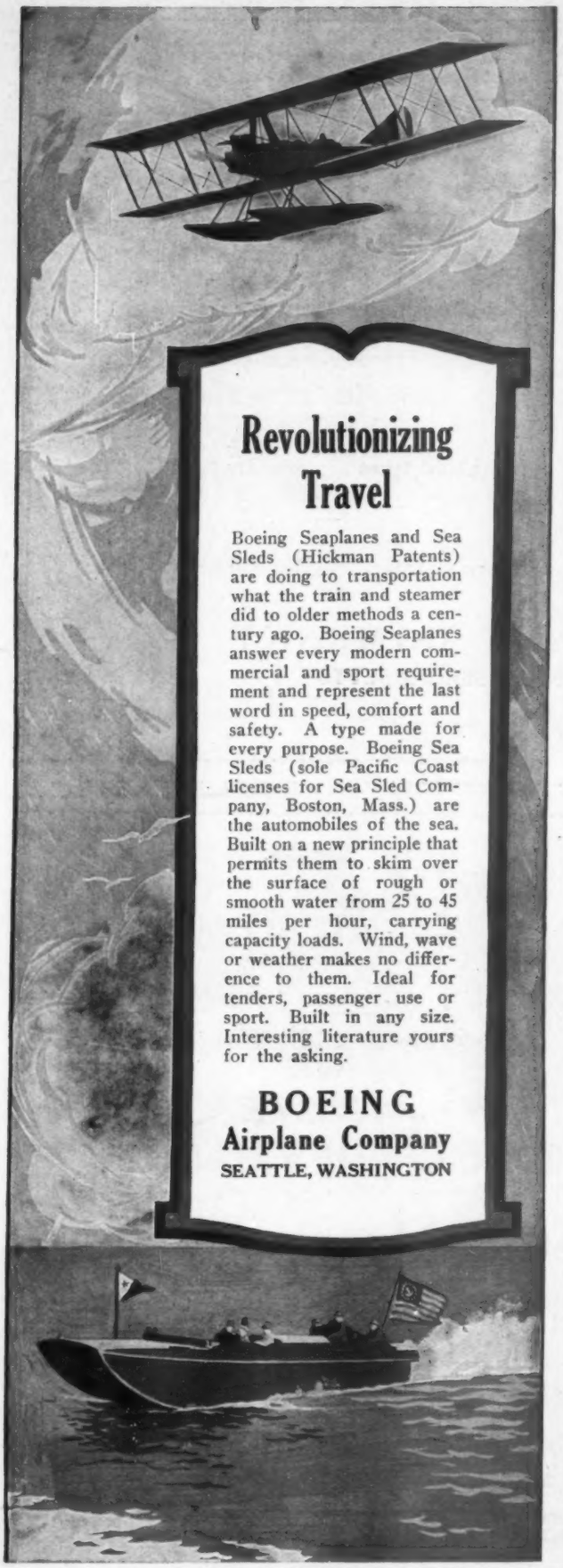

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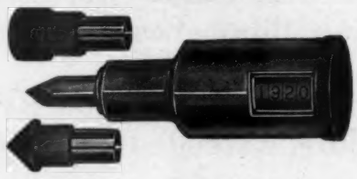

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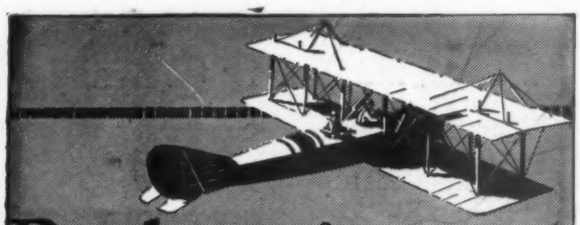

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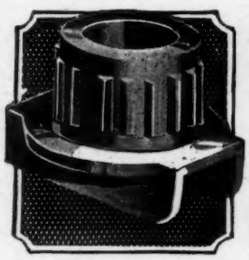

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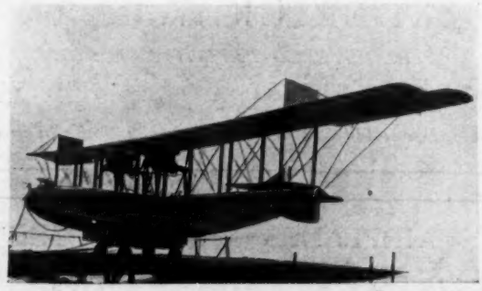

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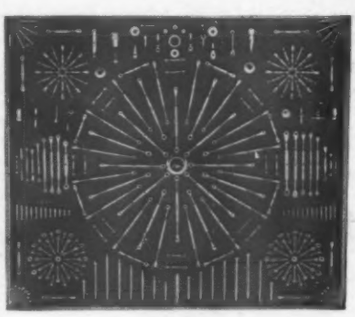

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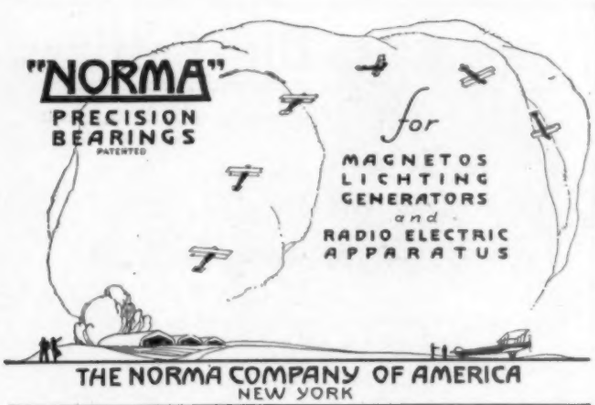

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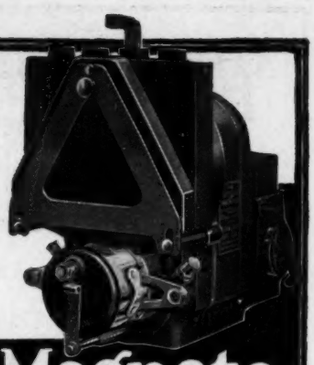

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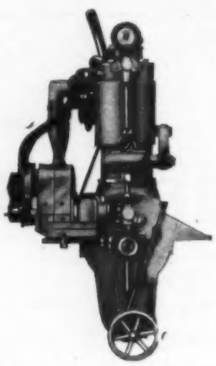

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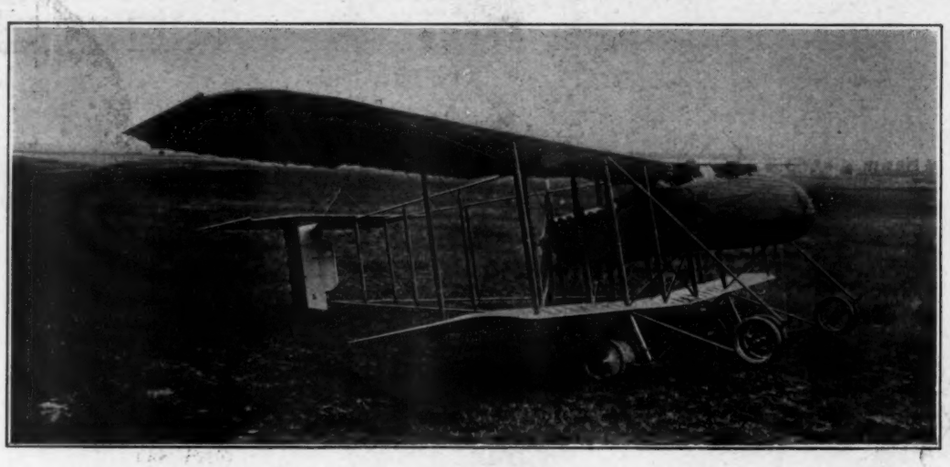

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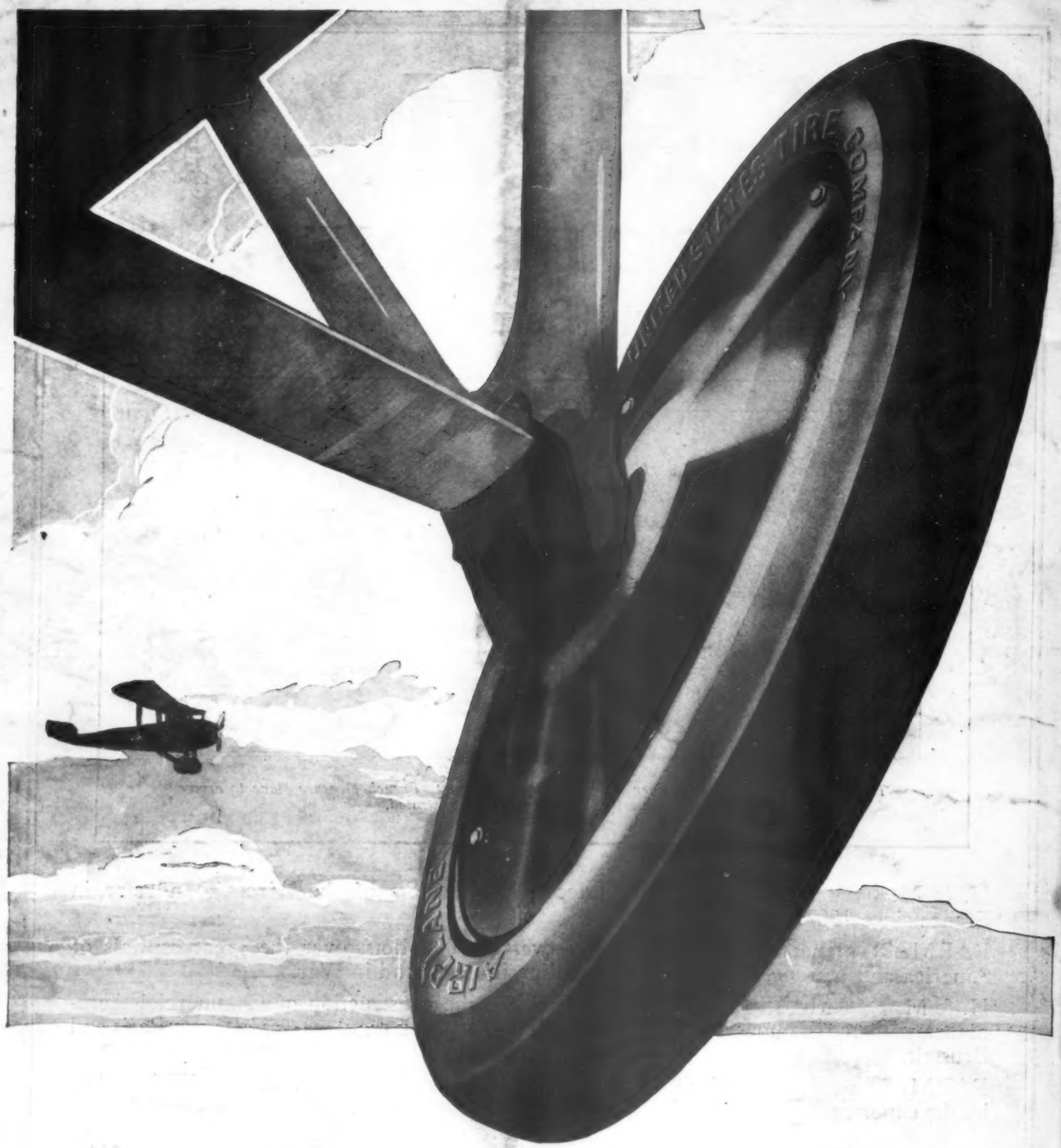

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